Algorithmic Trading

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Session I:
Introduction to algorithmic trading

The buzz-words

Decide with Confidence

Prop Trading	Agency Trading
Statistical, Volatility & Index Arbitrage	VWAP, TWAP
High/Ultra High Frequency Trading	Inline, Aggressive, Passive
Trend Following Systems	Dark Pool Execution
Factor Models	Smart Order Routing

What is Algorithmic Trading?

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- **al·go·rithm [noun]**

  A set of rules for solving a problem in a finite number of steps
- **Trade [noun, verb,** trad·ed, trad·ing, **adjective]**

  The act or process of buying, selling, or exchanging
- Algorithmic Trading: Set of rules for buying, selling or exchanging
- Rules are best followed by machines and not humans
- Humans have IQ and EQ
- Hence we let computers do the job

The myths and reality

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Myths	Reality
Oh! It is complex!	Set of simple rules, to make computers do the dirty job!
It's a Black Box!	Traders in India have been doing the same thing manually for decades
It's for PhD grads!	It's for everyone, who is competitive and future looking
It is expensive and pay-off is uncertain!	It is inexpensive, if priorities are right. Requires right approach and clear know-how of what you want!
It is for big boys!	Its for everyone from single traders to large houses

Why algorithmic trading?

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- Simple note
  - Trading is a mechanical job!
  - Everyone around us is doing it / thinking about it!
  - Hear more and more in the future!
  - Don’t want to miss the next bus!
  - Don’t want to feel left-out!
- Serious note
  - Build new revenue stream
  - Build competitive advantage
  - Solidify existing business and not lose it to others
  - Add value to existing clients
  - Attract new clients and investors

Prop Trading

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- Prop: Proprietary Trading
- Development of strategy for in-house trading and profitability

BSE-NSE Arb

Pair Trading Technical

Cash-Future Arb

Trend Following – Technical

Index Arb - Pure

Fundamentals on Equity Research

Agency Trading

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- Agency: Execution and brokerage services for the clients
- Development of strategy for superior client executions

Manual Order Slicing

Manual Directional Calls

Manual Market Making

Basic VWAP and Inline Engines

The building blocks

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Define End Goal

Define Set of Rules

Collect Data

Back-test

Optimize

Simulate

Connect to OMS

Connect to Exchange

Manage Risk

Improve and Maintain

Defining the end goal

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Nature

- Proprietary Trading
- Agency Trading
- Clients Trading (Wealth Management)

Frequency

- Low
- Medium
- High

AUM & Strategy

- Higher AUM, Long term return
- Lower AUM, Daily profits
- Non-correlated fresh strategy / Refine old ones

Defining the set of rules

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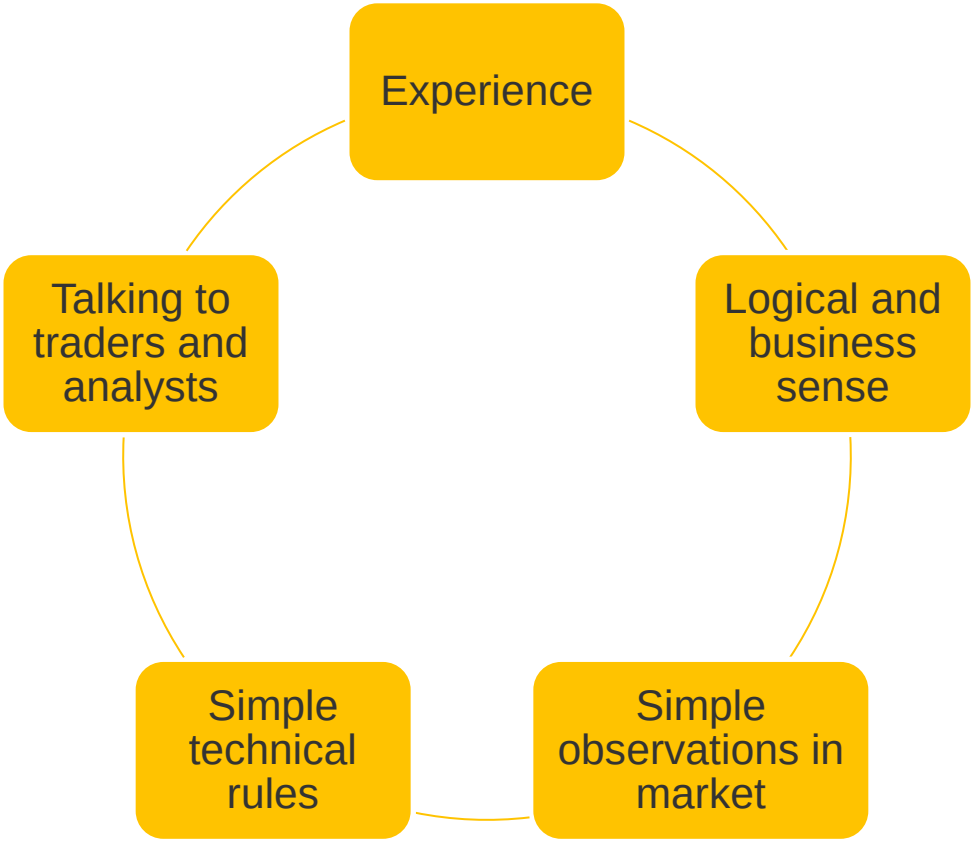

Exercises

Decide with Confidence

Exercise 1: Basic Modeling

Session II:
The mathematics of algorithmic trading

Why Mathematics & Statistics?

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Pure Technical Models	Technical & Statistical Models
Moderate ROI when model is working	Superior ROI when model is working
Large draw-downs when model stops	Flattish ROI when model stops
Long stretch of continuous bleeding in returns	Shorter stretch of continuous flattish period
User might lose confidence	User can diversify and make multi-models

The Mathematics

Decide with Confidence

Data Distributions

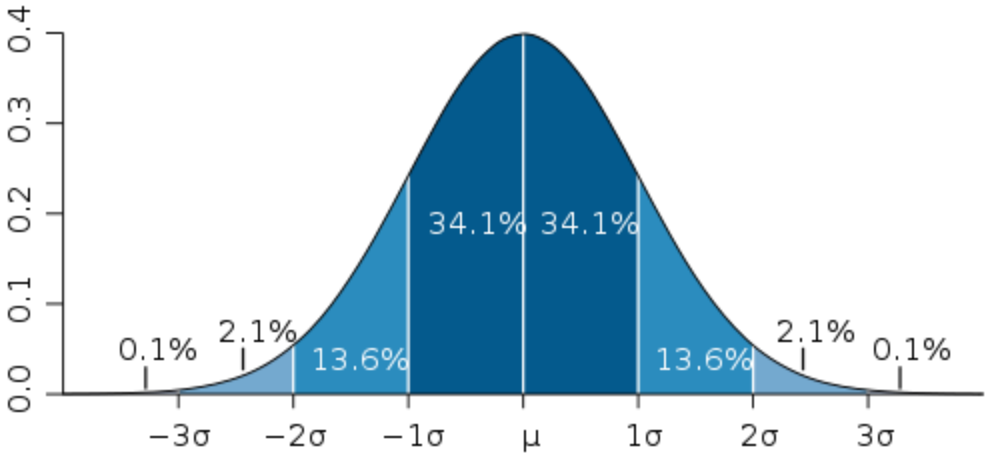
Time Series Modeling

Market Microstructure

The normal distribution

Decide with Confidence

- Most popular data distribution
- Standard normal distribution curve



Source: Wikipedia

The normal distribution

Decide with Confidence

- Mean

$$\mu = \frac{\sum x_i}{n}$$

- Standard deviation

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2}$$

- Variance

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2$$

- Correlation

$$r = \frac{Cov(x, y)}{\sigma_x \sigma_y}$$

- Beta

$$\beta_s = \frac{Cov(r_s, r_p)}{Var(r_p)}$$

Normal vs. other distributions

- Cauchy distribution
- Binomial Distribution
- Poisson Distribution
- Beta Distribution
- Chi-square Distribution
- Exponential Distribution
- Laplace Distribution

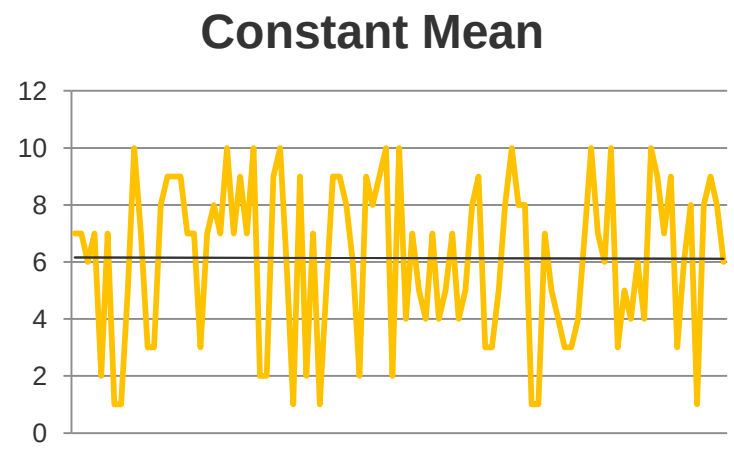
Time series modeling

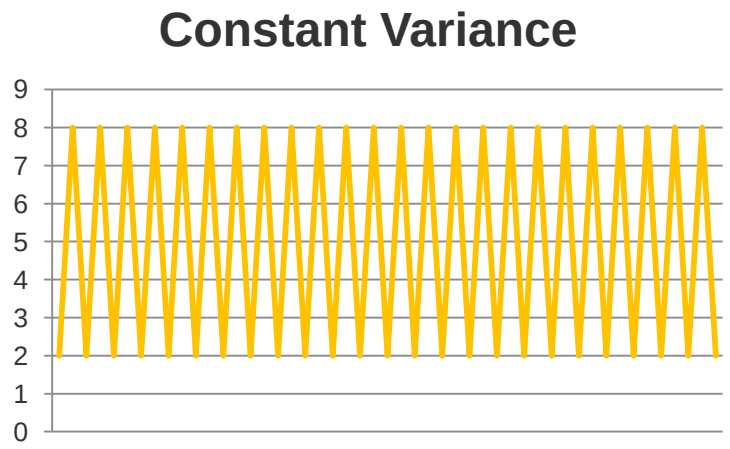
Decide with Confidence

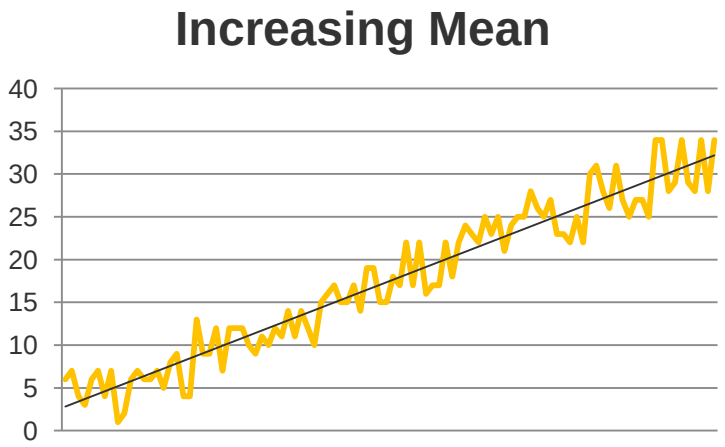
- Behavior of the time-series of data
  - Mean reverting, Trending or Random Walk
  - 50-60% time series is random walk
  - Focus should be on the other 40%
- Key elements: Mean and Variance
- Different behaviors
  - Mean reverting (E.g.: Pairs Trading)
  - Non-mean reverting (E.g.: Trend)
  - Constant variance (E.g.: Pairs Trading)
  - Increasing variance (E.g.: Trend)

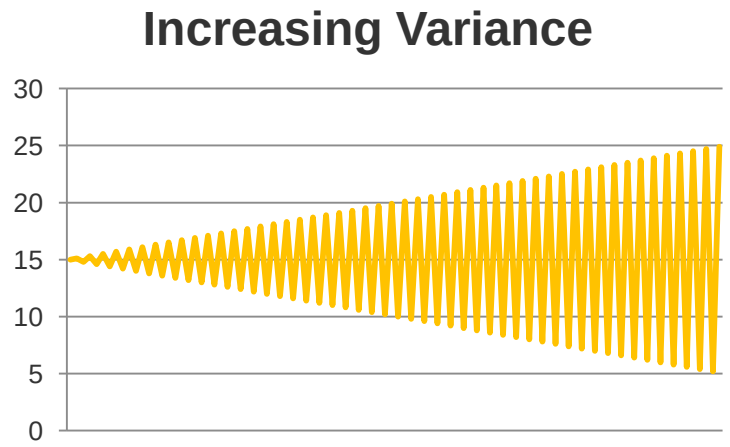
Mean and Variance

Decide with Confidence









Mean reversion modeling

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- Co-integration: Stationary mean and variance
- Time series is stationary when
  - The mean is constant
  - The variance is constant
- Test for co-integration
  - If |r| < 1, the series is stationary
  - If |r| = 1, it is non-stationary (Random walk)

$$y_t = ry_{t-1} + e_t$$

- Most popular test: ADF (Augmented Dickey Fuller)
- If ADF < -3.2 (95% probability of co-integrated series)

Generic time series modeling

Decide with Confidence

- Variance Ratio Test: Test for variance alone
- Useful when mean is varying w.r.t to the time

$$VR(k) = \frac{Variance(r_{k\Delta t})}{k \times Variance(r_{\Delta t})}$$

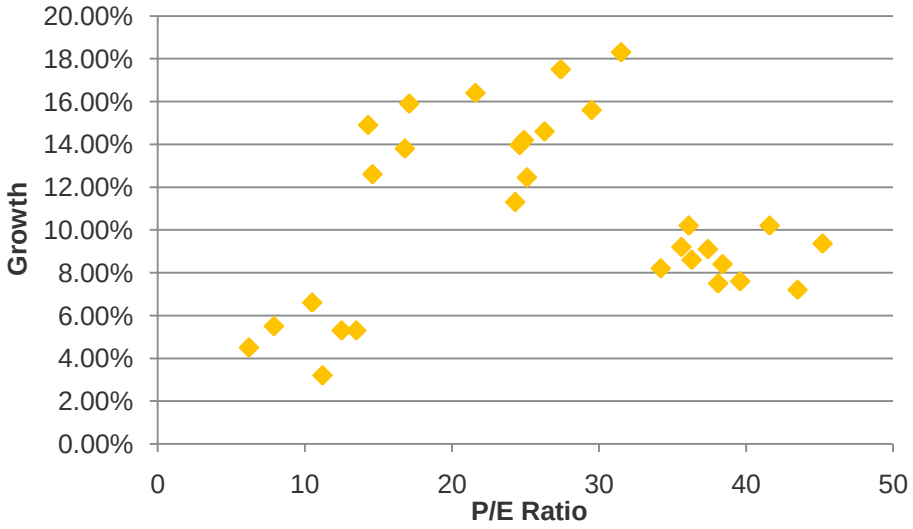
- Ornstein-Uhlenbeck Process: Test for mean reversion alone
- Useful when only mean reversion rate matters

$$dx_t = \theta(\mu - x_t)dt + \sigma dW_t$$

Cluster analysis and PCA

Decide with Confidence

- Grouping of similar data and pattern
- Useful in factor modeling
- PCA: To identify principal component



Regression

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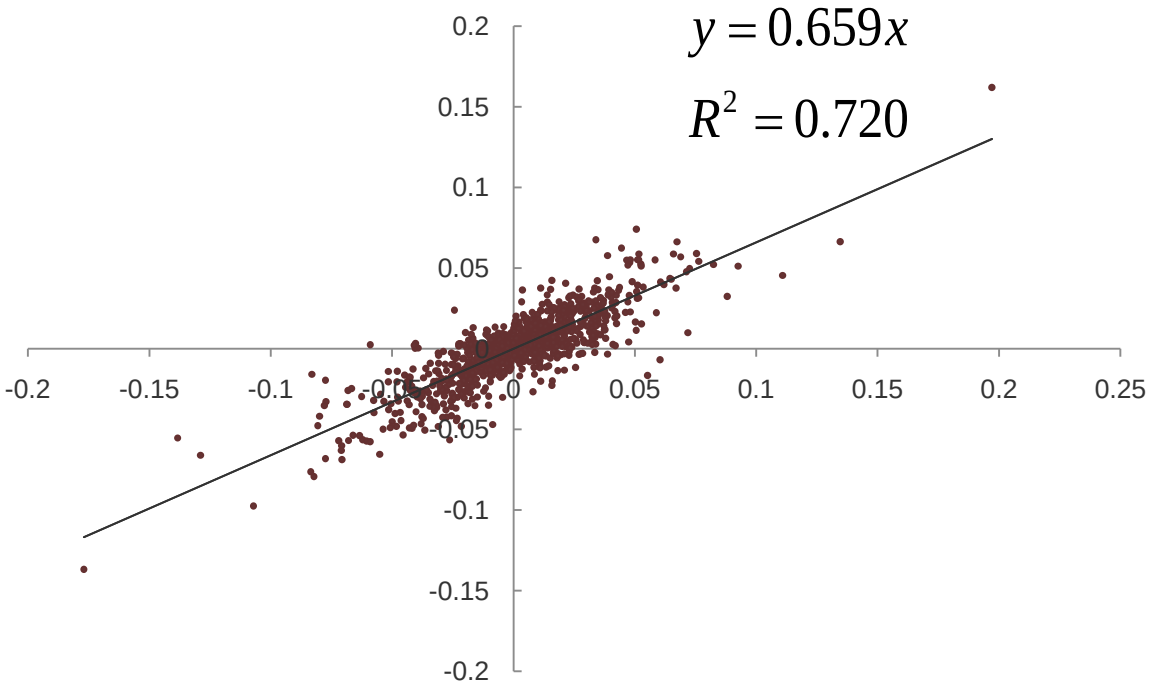
- Useful in identifying alpha-generating factors

$$y = mx + c$$



Exercises

Decide with Confidence

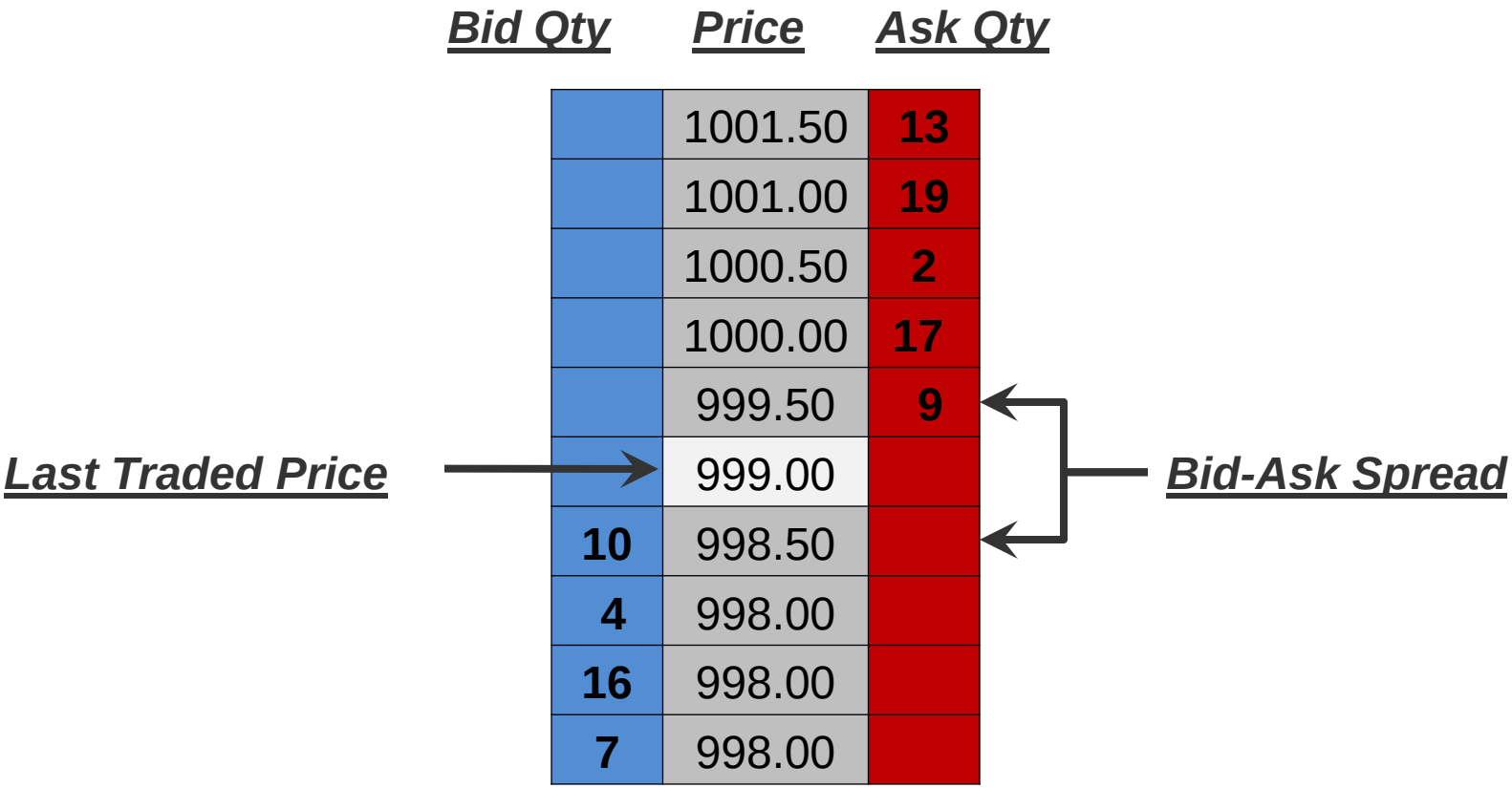
Exercise 1: Basic Modeling

Exercise 2: Time Series Modeling

Market microstructure

Decide with Confidence

- Used in UHFT, HFT, Agency Trading



The volatility

Decide with Confidence

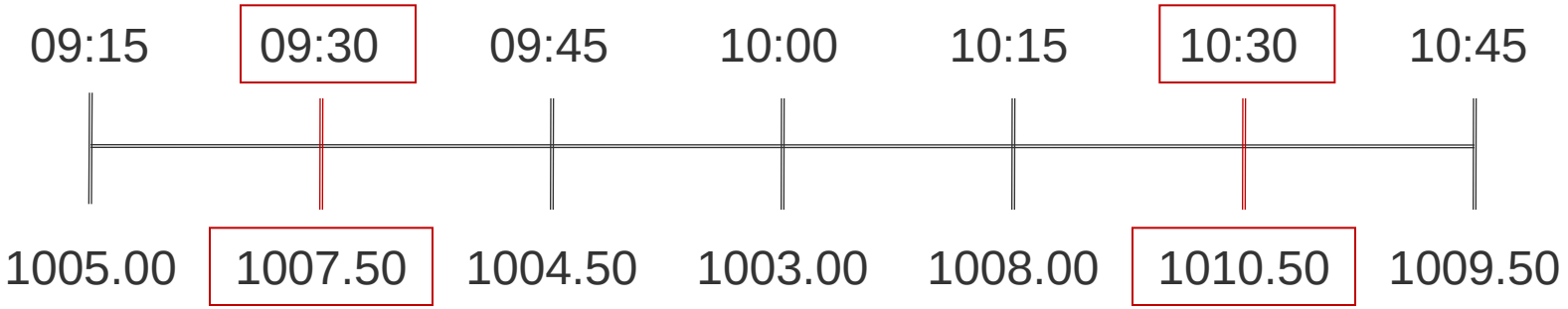
- Volatility is deviation from mean
- Volatility in daily, 5 min, 10 min etc.

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2}$$

Market microstructure

Decide with Confidence

- Market Price of Reliance in 5 min buckets



$$n = 5 \qquad \mu = 1006.70$$

$$\sum_{i=1}^{n} (x - \mu)^2 = 35.3 \qquad \boxed{\sigma = 2.657}$$

The spread

Decide with Confidence

- Spread in BP

$$Spread(BP) = \frac{(BestAsk - BestBid)}{(BestAsk + BestBid)/2} \times 10000$$

- Spread in ticks

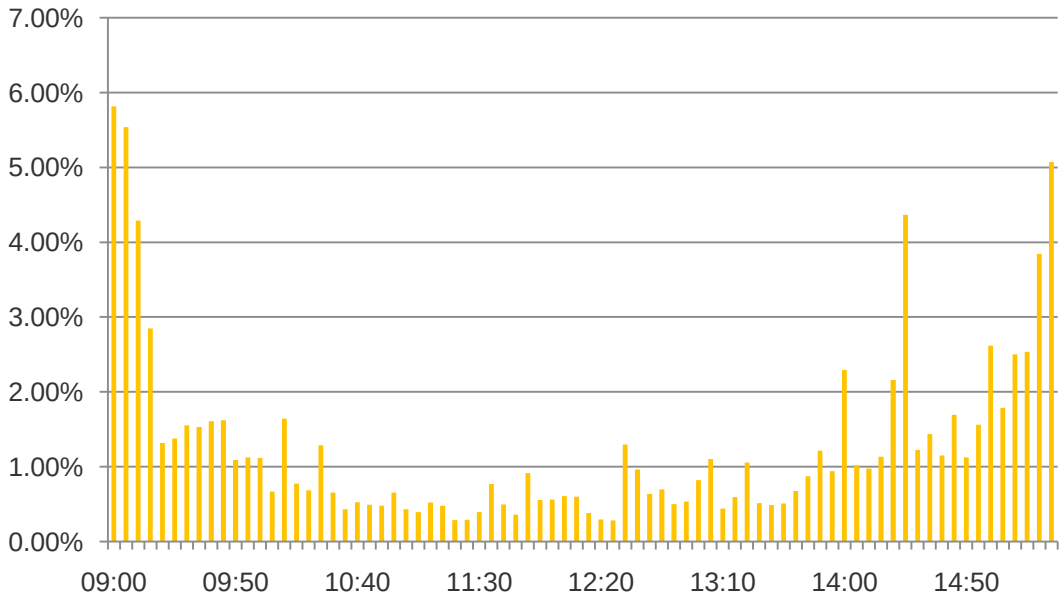
$$Spread(Ticks) = BestAsk - BestBid$$

The market curve

Decide with Confidence

- Volume / Market curve

$$VolumeRatio = \frac{BucketVolume}{DaysTotalVolume}$$



Session III:
Global trends in algorithmic trading

The size of algorithmic-trading

- TABB group reported in Aug'2009
  - 300 securities and large quant funds
  - Recorded $21 billion in profits in 2008!
- Pure high-frequency firms represents
  - 2% of the 20,000 trading firms in US
  - Account of 67% of all US volumes
- Total AUM of high-frequency trading funds
  - $141 billion
  - Down 21% from the high
  - Compared to global hedge fund shrinking by 33% since 2008

The volume rush

Decide with Confidence

- Volume Characteristics in US
  - In 2005 less than 25% of volume was from high-frequency
  - 2/3rd of daily US volume now from high-frequency strategies
  - HFT Strategy grew by 164% between 2005 and 2010
- Trading volume (Non-US)
  - Europe: 40% of trades
  - Asia: 5-10% (Growing extremely rapidly)

The Global Rush

Decide with Confidence

- All global I-bank has desk in algorithmic trading
- Risk savvy banks - higher Prop focus E.g.: GS (US Banks)
- Risk averse banks - higher Agency focus E.g.: CS (EU Banks)

Brokers Algorithmic Platforms

Decide with Confidence

I-Banks	Products	Selected Strategies
BoA	Electronic Trading Services (ETS)	VWAP, TWAP, TVOL, Razor, Market on Close, Arrival Price, Market Call
Citigroup	Alternative Execution	VWAP, TWAP, MOC and Participation
CS	AES	Slippage from Arrival Price, Reducing market impact, VWAP and In Line with Volume
GS	GSAT	VWAP, Implementation Shortfall, Piccolo (Small Order Spread Capture algorithm) and TWAP.

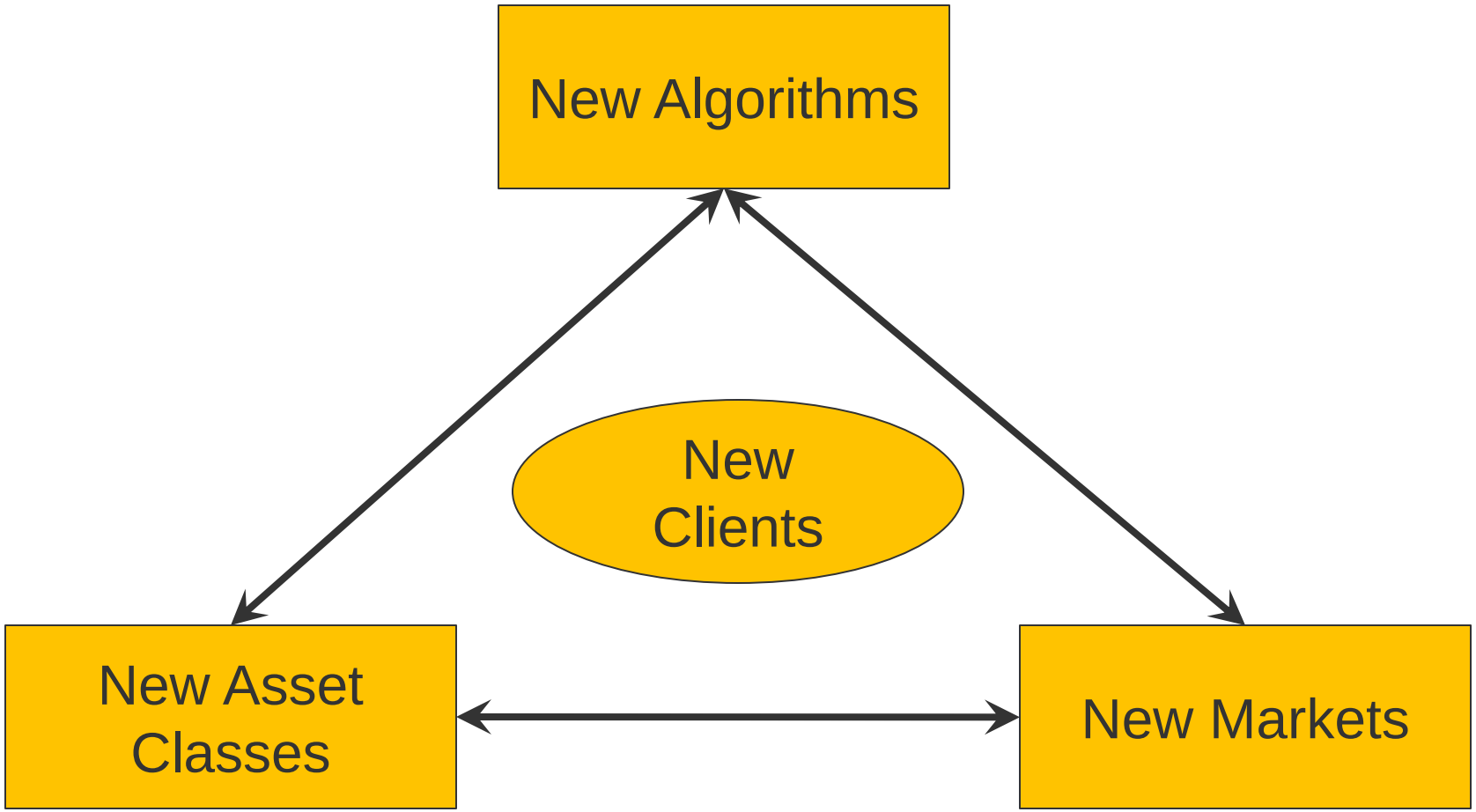
Brokers Algorithmic Platforms

Decide with Confidence

I-Banks	Products	Selected Strategies
ITG	SmartServer	VWAP, TWAP, Implementation Shortfall (Decision Price) and Market Close
JPM	Electronic Execution Services	VWAP and Implementation Shortfall (Arrival Price, Close Price) and a 'trader pre-defined benchmark
ML	ML X-ACT	OPL (Optimal), QMOC, VWAP, CLOCK (a TWAP engine), POV (Percentage of Volume) and TWIN (trades two stocks based on a price per ratio or spread).

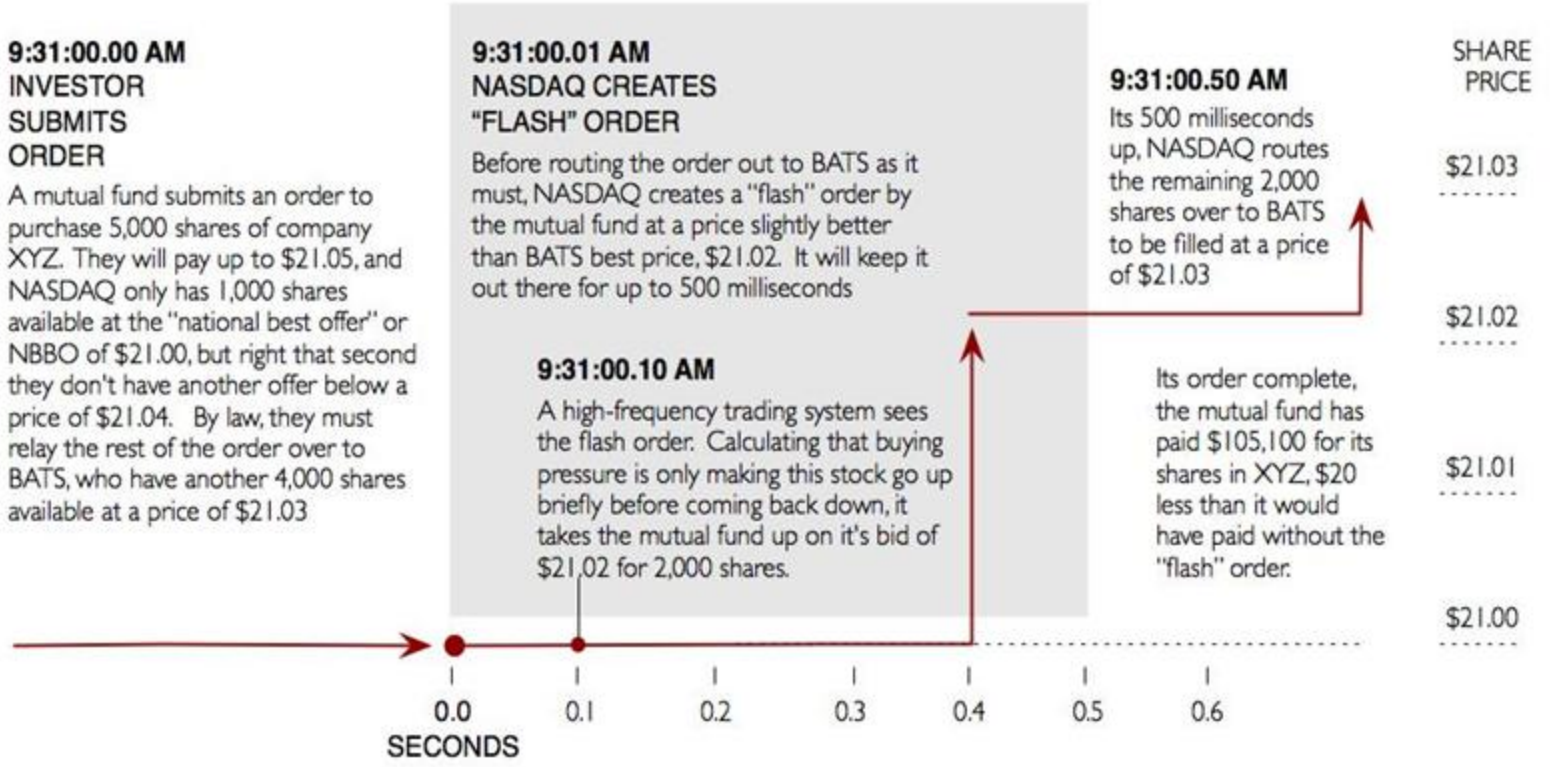
The Growth Path

Decide with Confidence



Algorithms across Exchanges

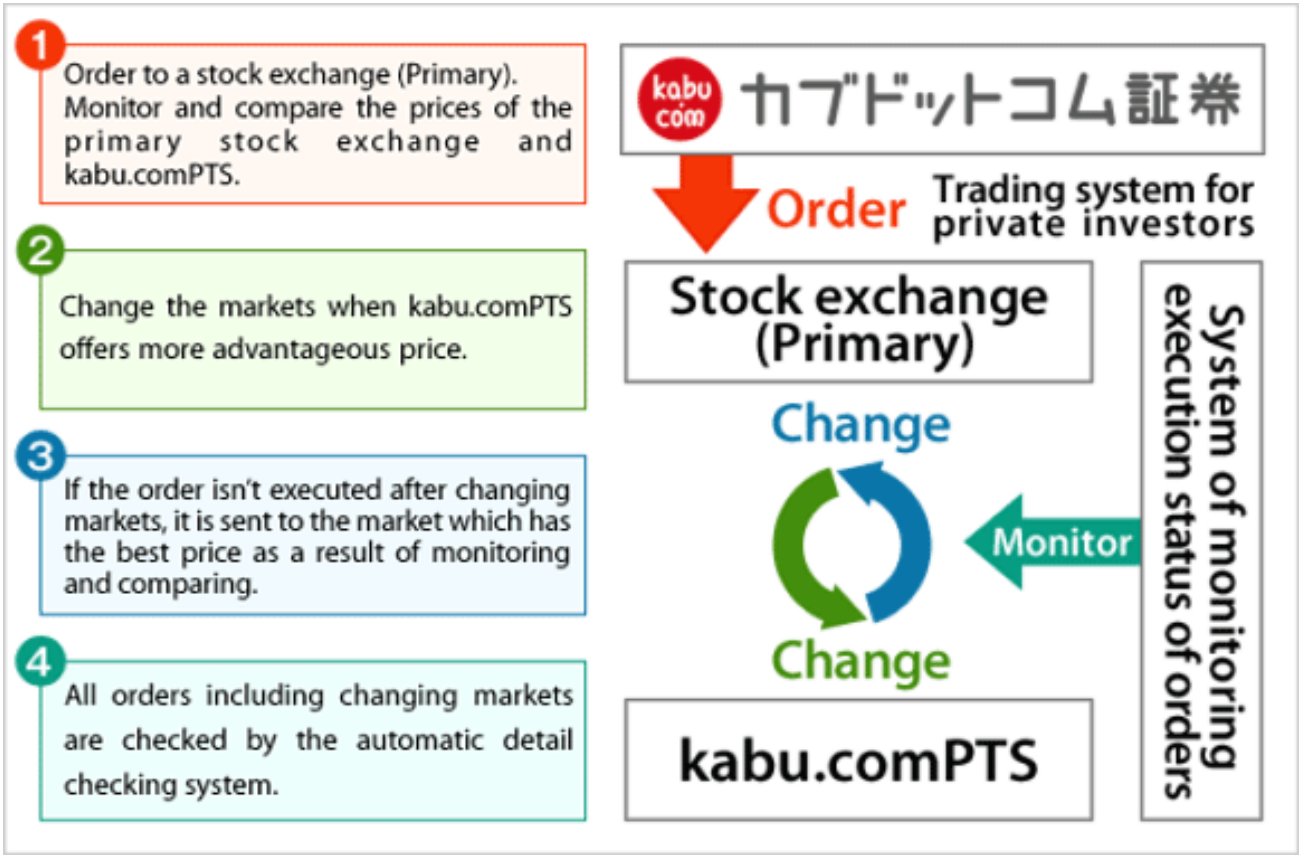
Decide with Confidence


9:31:00.00 AM
INVESTOR SUBMITS ORDER
A mutual fund submits an order to purchase 5,000 shares of company XYZ. They will pay up to $21.05, and NASDAQ only has 1,000 shares available at the "national best offer" or NBBO of $21.00, but right that second they don't have another offer below a price of $21.04. By law, they must relay the rest of the order over to BATS, who have another 4,000 shares available at a price of $21.03
9:31:00.01 AM
NASDAQ CREATES "FLASH" ORDER
Before routing the order out to BATS as it must, NASDAQ creates a "flash" order by the mutual fund at a price slightly better than BATS best price, $21.02. It will keep it out there for up to 500 milliseconds
9:31:00.10 AM
A high-frequency trading system sees the flash order. Calculating that buying pressure is only making this stock go up briefly before coming back down, it takes the mutual fund up on it's bid of $21.02 for 2,000 shares.
9:31:00.50 AM
Its 500 milliseconds up, NASDAQ routes the remaining 2,000 shares over to BATS to be filled at a price of $21.03
Its order complete, the mutual fund has paid $105,100 for its shares in XYZ, $20 less than it would have paid without the "flash" order.
SHARE PRICE
$21.03
$21.02
$21.01
$21.00
0.0
0.1
0.2
0.3
0.4
0.5
0.6
SECONDS

Source: www.thefinanser.co.uk

Algorithms across Exchanges

Decide with Confidence


1
Order to a stock exchange (Primary). Monitor and compare the prices of the primary stock exchange and kabu.comPTS.
2
Change the markets when kabu.comPTS offers more advantageous price.
3
If the order isn't executed after changing markets, it is sent to the market which has the best price as a result of monitoring and comparing.
4
All orders including changing markets are checked by the automatic detail checking system.
kabu com
カブドットコム証券
Order
Trading system for private investors
Stock exchange (Primary)
Change
Monitor
Change
kabu.comPTS
System of monitoring execution status of orders

Source: www.kabu.com

Exercises

Decide with Confidence

Exercise 1: Basic Modeling

Exercise 2: Time Series Modeling

Exercise 3: High Frequency Modeling

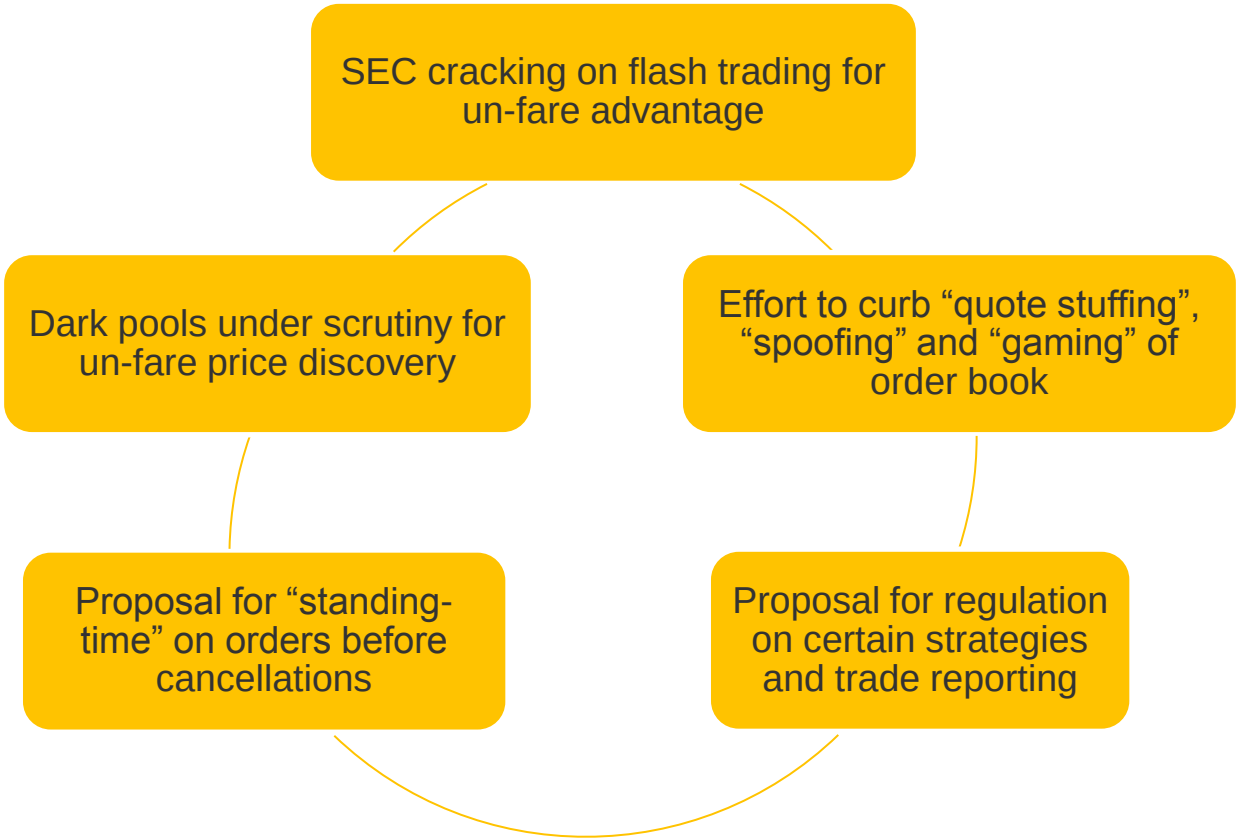
The Geographical Divide

Decide with Confidence

- Matured markets
  - E.g.: US, Japan
  - Getting to next stage of bleeding edge innovation
  - Cut throat competition to save every 1 BP in Agency
  - Cut throat competition for every percentage of additional alpha
  - Lateral shift to ultra-high frequencies and nano second latencies
- Growing markets
  - Understanding the implications of algorithmic trading
  - Coming in sync with investors and their growing execution needs
  - Computer algorithms eating the bread-and-butter strategies
  - E.g.: Perish of pure Index arbitrage, BSE/NSE arbitrage in India

The Regulatory Structure in US

Decide with Confidence


SEC cracking on flash trading for un-fare advantage
Effort to curb “quote stuffing”, “spoofing” and “gaming” of order book
Proposal for regulation on certain strategies and trade reporting
Proposal for “standing-time” on orders before cancellations
Dark pools under scrutiny for un-fare price discovery

Session IV:
Lifecycle of Algorithmic Trading

Lifecycle of Algorithmic Trading

Decide with Confidence

- Strategy/Pattern Recognition
- Data Gathering/Data Cleaning
- Back Testing
- Factor Optimization
- Monte Carlo Simulation (Parameter Optimization)
- Trade/Portfolio Result Analysis
- Simulated Trading/ Risk Management
- Live Trading and Execution

Identify Trading Patterns

Decide with Confidence

- Talk to experienced traders
- Talk to clients
- Read books and articles on internet and trade magazines
- Watch market movements (Intra-day, Daily)
- Test simple technical patterns on excel sheets
- Brainstorm and team approach
- Technical analysis is very useful to get the initial signal

Back-testing

Decide with Confidence

- Most critical element of algorithm development
- Why back-test?
  - Avoid past mistakes
  - See repeated ness of a pattern
  - Analyze risk, reward, pit-falls etc.
  - Analyze robustness across different market environment
- Back-test data: bearish, bullish and range-bound markets
- In-sample and out-of-sample testing
- How?
  - Programming: Excel, VB Macros, Java, C++
  - Statistics: Matlab, R, Python

Steps in back-testing

Decide with Confidence

- Data Gathering and Cleaning
- Back testing the trading strategy
- Regressing against profitable factors
- Analyzing Trade/Portfolio Return
- Drawing Return Curve
- Analyzing Sharpe Ratio and Max Drawdown
- Re-run the back tests

Exercises

Decide with Confidence

- Exercise 1: Basic Modeling
- Exercise 2: Time Series Modeling
- Exercise 3: High Frequency Modeling
- **Exercise 4: Back testing**

Alpha generation

Decide with Confidence

- Identifying factors to improve profitability
- E.g.:
  - Pair-trading: co-integration, beta
  - Trend following: SMA, EMA or MACD
  - High frequency: Bid to Offer ratio for short term long position
- Use statistical and mathematical factors
- Mathematical modeling
  - Price pattern broken into deterministic and random components
  - Modeling the deterministic component of the time series
- Regression of trade return vs. statistical factors
- Caution: Factors make intuitive, logical and business sense

Monte-Carlo simulation

Decide with Confidence

- Identifying optimal parameters for each factor
- Tests carried across multiple values for one or more factors
- E.g.:
  - Value of z-score in pair trading (-1.5, -2, -2.5 etc.)
  - Moving average length: 20 period, 50 period etc.
- Optimal solutions is tested for
  - Annualized percentage return
  - Max peak to trough drawdown
  - Average peak to trough drawdown
  - Annualized Sharpe ratio
  - Maximum non-performing period
- Caution: Avoid over-optimization and data-fitting

Transformation – Trade to Equity Curve

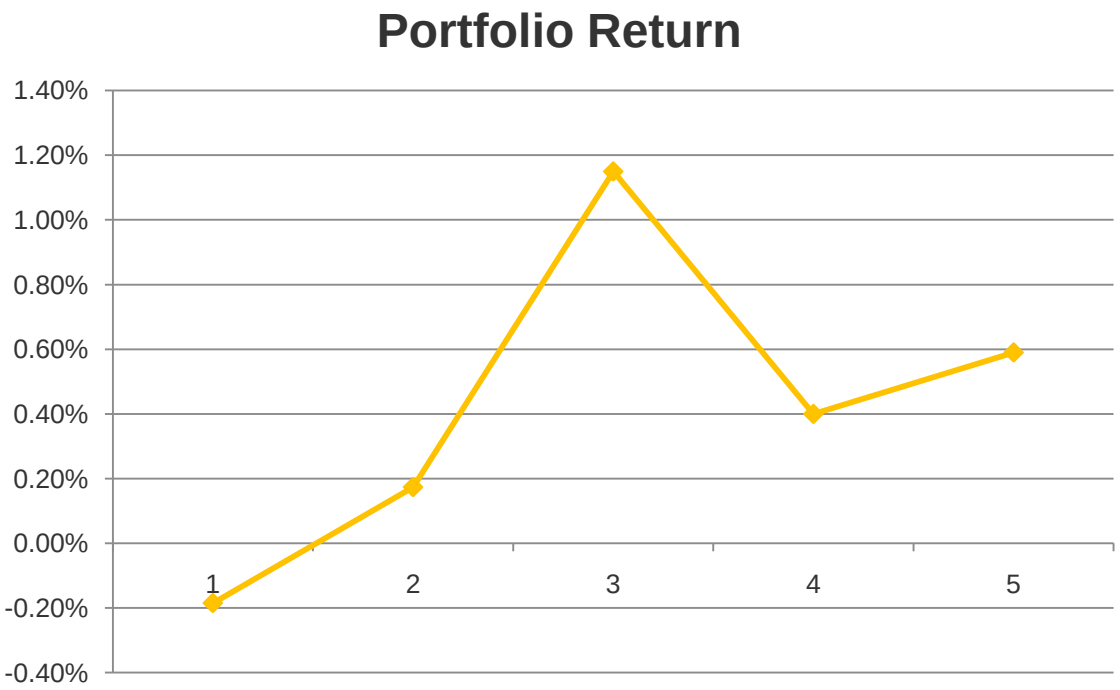
Decide with Confidence

- Trade 1: Buy Tata Motors, 11th Oct, 2010 @ 767.00
  Sell Tata Motors, 15th Oct, 2010 @ 791.00 (+3.13%)
- Trade 2: Buy Tata Steel, 11th Oct @ 644.75
  Sell Tata Steel, 13th Oct @ 632.25 (-1.94%)

Date	Tata Motors	Tata Steel	Trade1 Return	Trade2 Return	Portfolio Return
11th Oct	771.00	639.00	0.52%	-0.89%	-0.19%
12th Oct	783.65	633.10	1.64%	-0.92%	0.18%
13th Oct	800.00	632.25	2.09%	-0.13%	1.16%
14th Oct	788.00		-1.50%		0.41%
15th Oct	791.00		0.38%		0.60%

The equity curve (portfolio return)

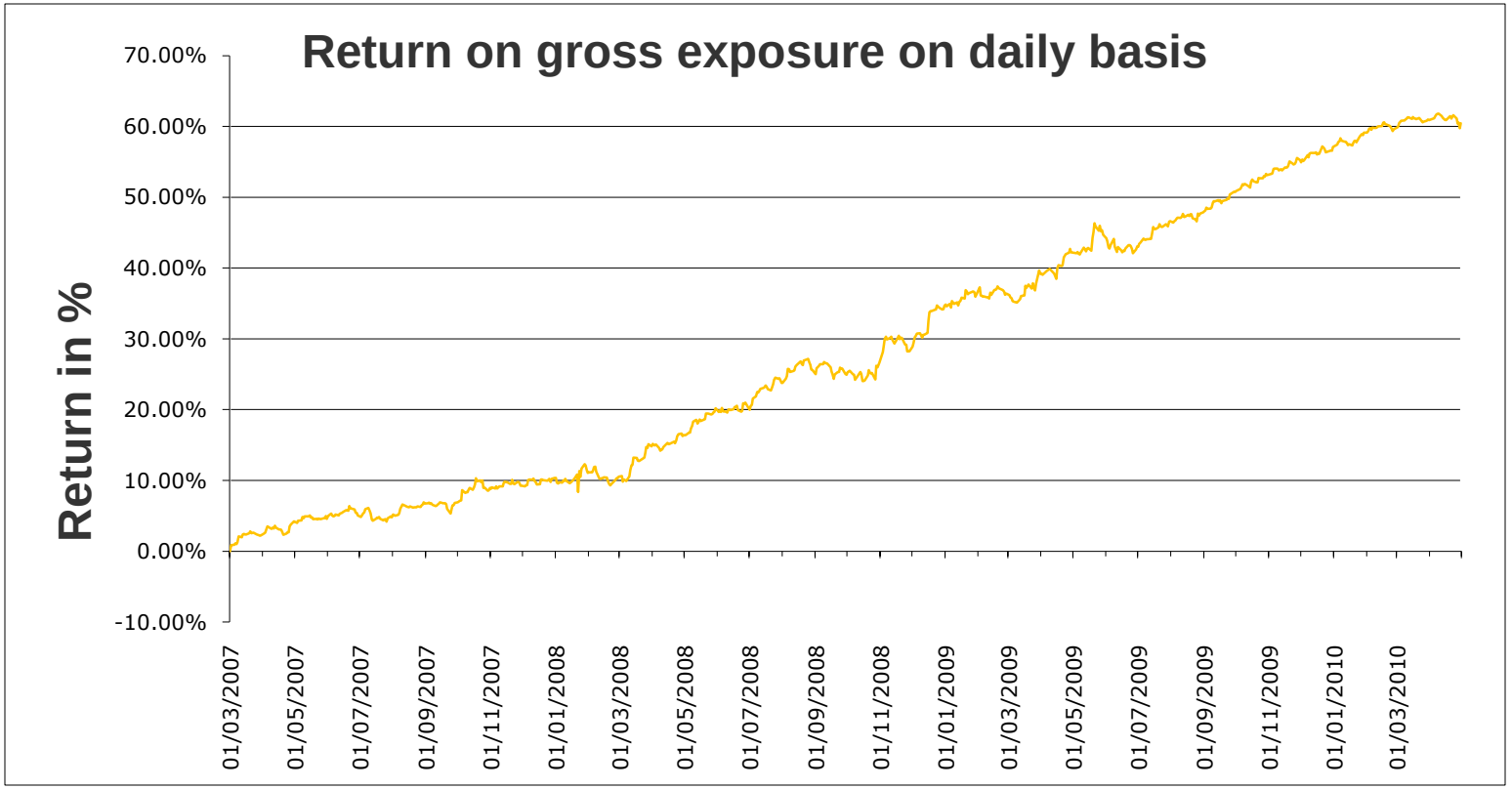
Decide with Confidence



The Equity Curve

Decide with Confidence

- It is a graphical representation of the growth of the portfolio in the terms of profit returns achieved



The Litmus Tests

Decide with Confidence

- Peak to Trough Drawdown: Maximum retrenchment of portfolio returns in the equity curve
- Annualized Percentage Return

$$R = r \times T$$

- Annualized Sharpe Ratio

$$SH = \frac{r - r_0}{\sigma} \times \sqrt{T}$$

Where
R = Annualized percentage return
r = Average Daily Return
r_0= Daily risk-free rate of return
T = No. of Trading days in the year
σ = Std Dev of Daily Returns

Stress Test

Decide with Confidence

- 3 std-dev (1 in 25 years) happens every 6 months
- 10 std-dev (1 in 500 years) happens every 2 year
- Effect of “very fat-tails” in algorithmic trading
- Stress testing with dynamic and random price series
- Analyze large losses and unforeseen drawdown
- Work on optimization and event-risk

Simulated Trading

Decide with Confidence

- Most algorithmic trading fails because of
  - Lack of execution know-how
  - Gaps between back-test and real-life execution
  - Slippages, transaction costs and other charges
  - Increasing size and quantity beyond the model capacity
- Simulated trading is important
  - Trades signal are generated at right time
  - Execution pit-falls are ironed out
  - Slippages w.r.t to the signals are minimized
  - Real-life trading is consistent with back-testing
- Usual period: 3 weeks to 3 months
- After 3 weeks, start real-life trading with minimal quantity

Automated execution

Decide with Confidence

- Reduce the time between signal and execution
- Non-emotional and systematic approach
- No view-point or self-analysis overlay on the signals
- Execute orders using
  - An execution guy, punching the order as it appears (low-cost)
  - CTCL connectivity of NSE provided by 3rd party vendor software
  - DMA platform provided by Institutional brokers
  - DSA platform provided by Institutional brokers
  - FIX protocol (global standard) for information exchange
  - In future: Agency algorithms (VWAP, Passive etc.) for execution

Going live

Decide with Confidence

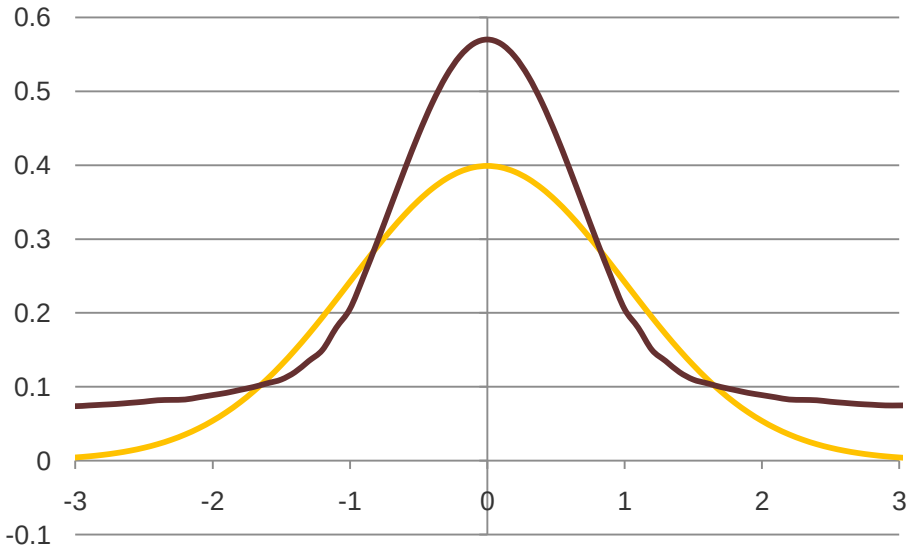
- Risk: Limit on daily turnover and on each trade execution
- Commit to a strategy for a longer term (1 year at least)
- Start small and consistent quantity and size
- Set aside a draw-down and stop loss limit (E.g.: Rs.10 lacs)
- E.g.: I don’t know, I don’t care, I know my stop-loss
- Don’t change the quantity and trading sizes abruptly
- Understand the flattish period in the performance
- Calculate daily
  - Gross & Net exposure
  - VAR (Value-At-Risk)
  - Daily Profit/Loss and returns on gross exposure
- Avoid excess leverage

Session V:
Risks, Returns & Roles in algorithmic trading

What is Risk?

Decide with Confidence

- Deviation from possible outcomes
- Fat-tails in the market
- Risks: Systematic and Non-systematic



Systematic Risks

Decide with Confidence

- Systematic Risks
- We can foresee and prepare for these risks
- Market direction risk, net rupee exposure
- Sector risk
- Single stock risk (E.g.: Satyam)
- Slippage risk
- Execution risk (software crash, power failure etc.)

Systematic risk mitigation

Decide with Confidence

- In design
  - Market direction, net rupee risks / Market direction neutral
  - Single sector exposure risks (< y% of the portfolio)
  - Single stock exposure (< x% of the portfolio)
- During execution
  - Design to take order book (bid and ask) into account
  - Caps on daily turnover in the system
  - Caps on single trade max rupee value to be executed
  - Caps on number of trades in a day
  - System should handle power failure and software crash
- When live
  - Live monitoring by the IT people on connectivity, re-start etc.
  - Switch-on and Switch-off during rare market circumstances

Non systematic risks

Decide with Confidence

- Event risk
  - E.g..: India elections 17th May'2009
  - Large losses, if caught on the wrong side of the market
  - Less frequent in nature
- Algorithmic wars (New age nuclear war!)
  - More prevalent in matured and 100% electronic markets
  - Triggered when a profitable algorithm becomes too crowded
  - Usually presided by a very profitable period
  - Then stop-losses trigger and some large funds unwind
  - Leads to "ripple-effect", causing large movements in the positions

Examples when algorithm fails

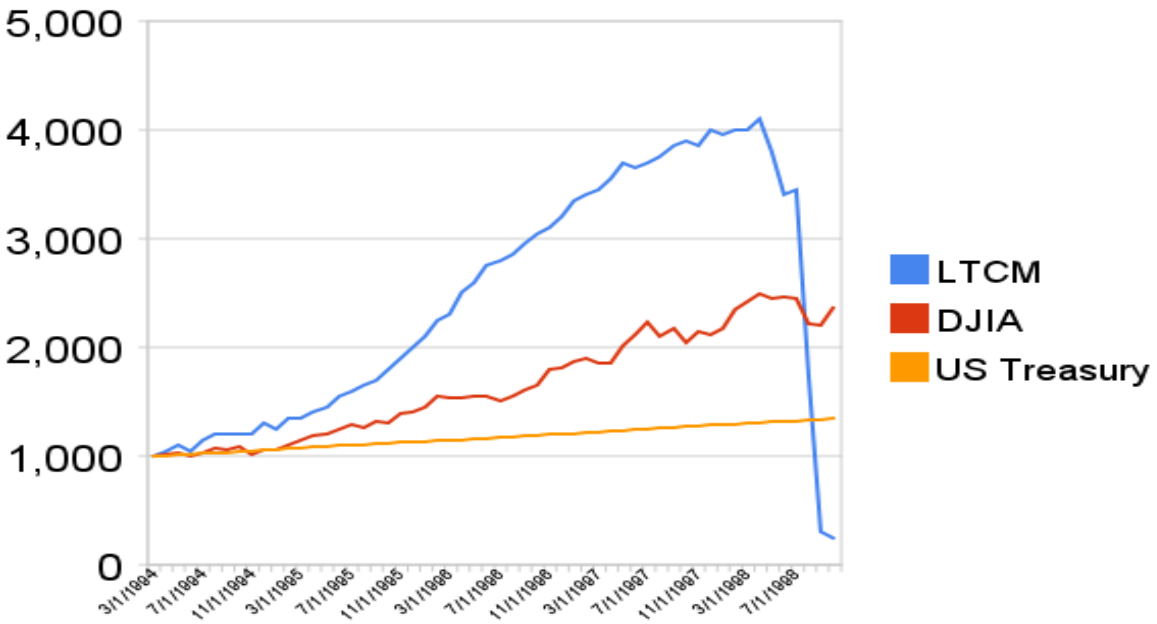
Decide with Confidence

- October'1987 US stock market crash: Automated trading
- August'2007 Quant meltdown: Crowded factor model
- May 6th 2010, US Intraday movement: Crowded high frequency

Examples when algorithm fails

Decide with Confidence

- Long Term Capital Management
  - Founded in 1994 by John Meriwether and Myron Scholes
  - 40% annualized returns after fees in first 3 years
  - Lost $4.6 Bn. in 1998 within 4 months



Source: Wikipedia

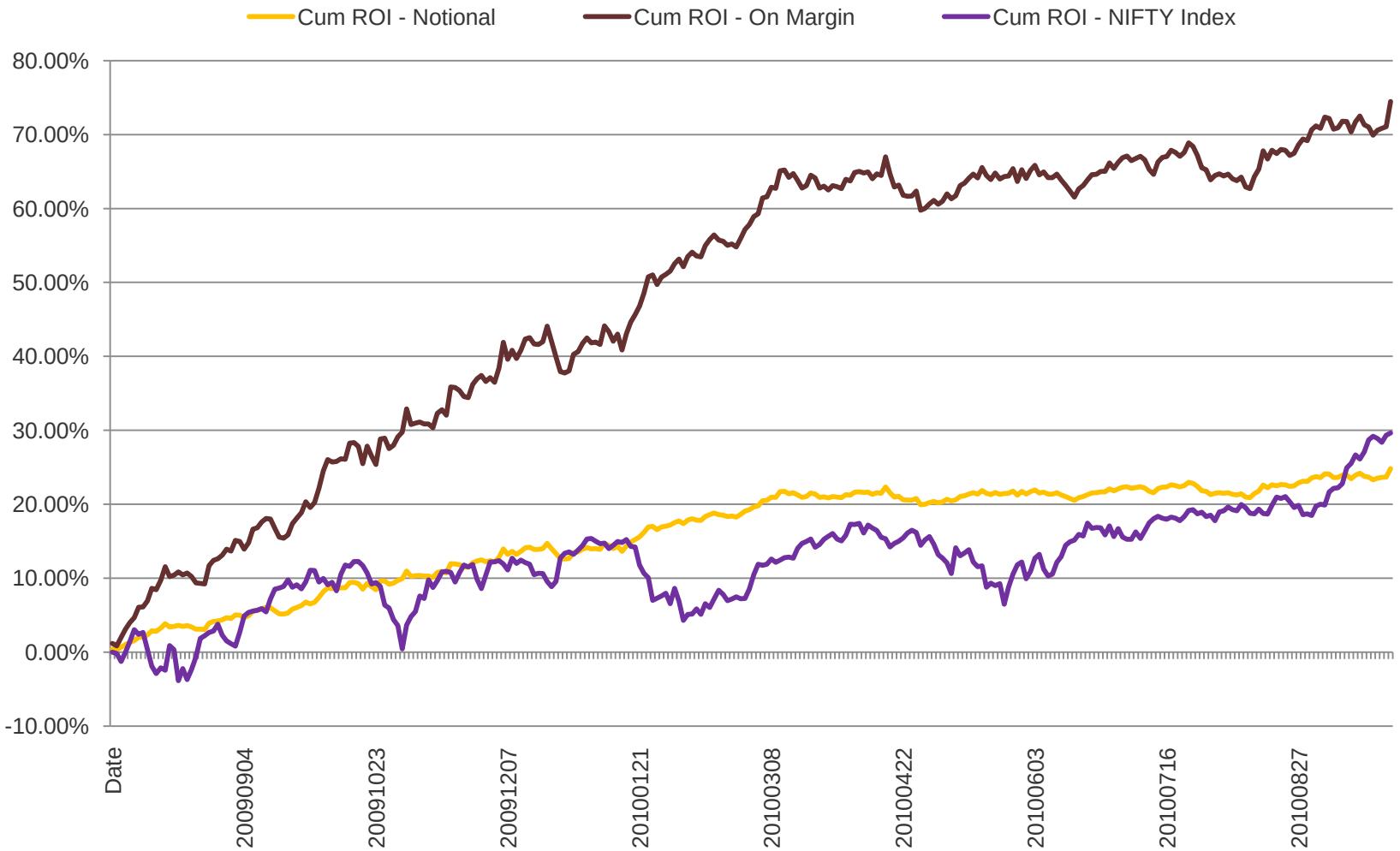
The returns

Decide with Confidence

- Strategies to yield returns on market direction / direction-less
- Once designed properly, can become a cash-cow
- Lesser players implies higher returns
- Returns in India
  - Stat-arb strategies: 25-40% returns
  - Ultra high frequency: Deterrent in India due to STT costs
  - Trend following and momentum strategies: 25-35 % returns
  - Long/Short equity strategies: 20-25% returns
  - Intra-day / BTST-STBT strategies: 30% returns
- Best quant funds: Renaissance Technologies & DE Shaw
- More then 20% p.a. returns after fees for last 20 yrs.

Example: Pair-trading in India

Decide with Confidence



Costs

Decide with Confidence

Securities Transaction Tax

Product	Transaction	STT rate	Charged on
Equity-Delivery	Purchase	0.125%	Turnover
	Sell	0.125%	Turnover
Equity-Intraday	Purchase	-	-
	Sell	0.025%	Turnover
Future	Purchase	-	-
	Sell	0.017%	Turnover
Option	Purchase	0.125%	Settlement price, on exercise
	Sell	0.017%	Premium

Other Charges on Futures

SEBI Turnover Charges	0.0001%
Transaction Charges	0.002%
Total Charges on Futures (Buy & Sell) = 1*1.7 BP+2*0.01 BP+2*0.2 BP	2.12 BP (0.0212%)

The major costs

Decide with Confidence

- Slippages
  - India has lowest spreads in Asia: 5 BPS
  - Indian market lacks order book depth
  - Liquidity dries beyond top 70-80 stocks
  - Options: Index and top 7 scrip
  - Hence, slippages occur while executing large orders
  - Trick: Capture the Indian market breadth and NOT depth
- Brokerage
  - Understand the average per trade return
  - High frequency ~ 0.08%-0.30% per trade
  - Medium frequency ~ 0.8% to 2% return per trade
  - Low frequency ~ 2% to 10% return per trade
  - Hence brokerage should be at 0.02% and below in high-frequency
  - Can be larger 0.02% to 0.05% for medium to low frequency trades

Roles - Trader

Decide with Confidence

- Identify trading patterns and strategies
- Watch market movements and opportunities
- Give practical experience & feedbacks
- Work closely with IT and quant team
- Check the back tests and historical performance closely
- Monitor live time risk and positions

Roles - Quant

Decide with Confidence

- Convert “business language” into “mathematical language”
- Gather and clean data
- Back-test strategies
- Identify alpha generating factors using statistical tools
- Build simulated trading environment
- Test strategies in live market
- Take feedbacks and risk-control measures from traders

Roles - IT

Decide with Confidence

- Convert “mathematical language” into “computer language”
- Support Quant in building the IT systems
- Develop processes to store, clean and manage data
- Develop systems to back-test and simulate
- Develop system to manage order execution
- Support the end-to-end lifecycle of algorithm development

Roles – risk manager / compliance

Decide with Confidence

- Risk assessment on strategy level and daily VAR levels
- Analyze correlation between various strategies
- Assess limits and exposures in each strategies
- Ensure compliance with SEBI and exchange regulations
- Ensure that trades send to the market uses standard connectivity protocols
- Ensure provision in system to restrict certain stock
- Inform higher management towards unforeseen risks

Exercises

Decide with Confidence

- Exercise 1: Basic Modeling
- Exercise 2: Time Series Modeling
- Exercise 3: High Frequency Modeling
- Exercise 4: Back testing
- **Exercise 5: Variance Ratio Calculation**

Session VI:
The trading strategies

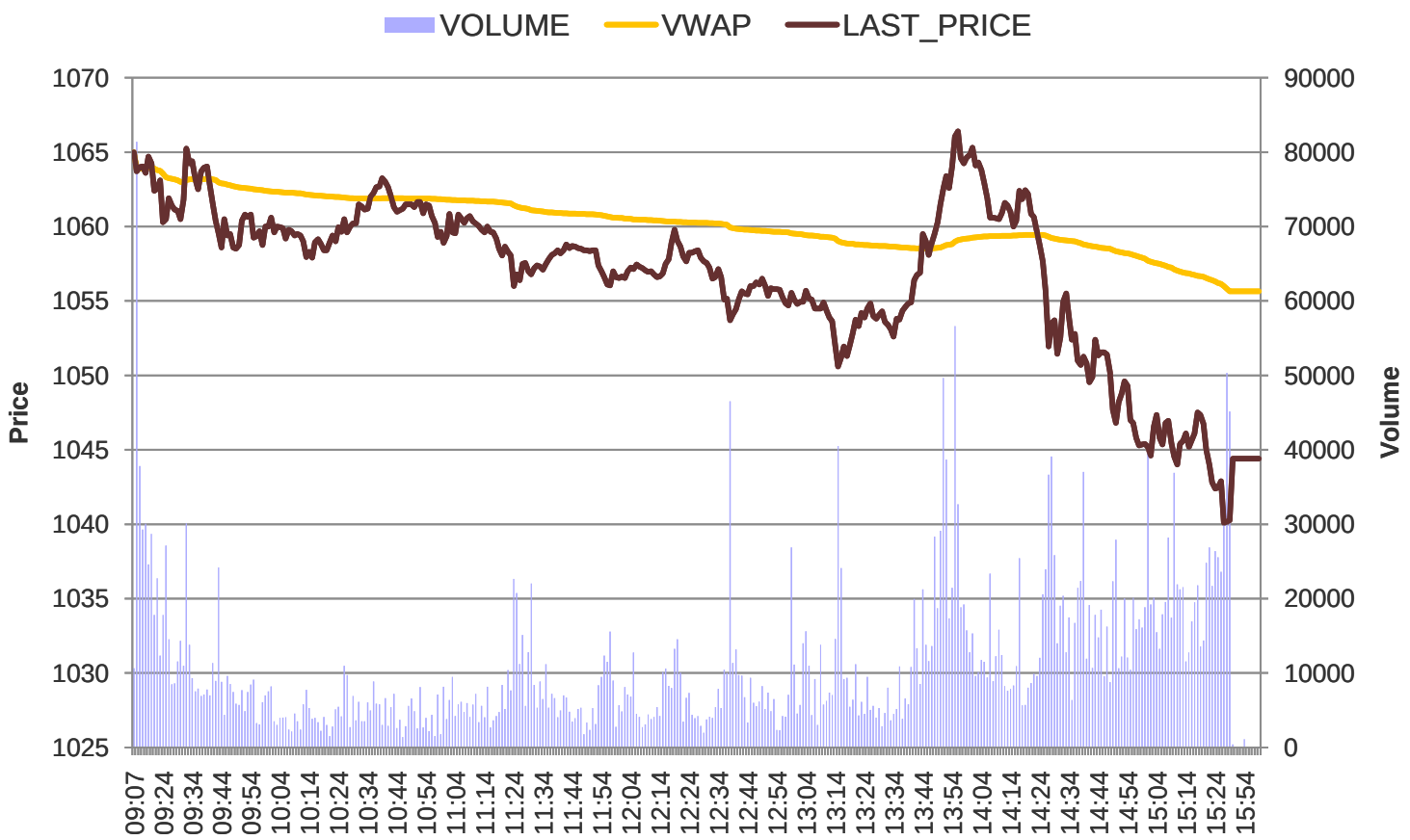
Agency algorithms

Decide with Confidence

- Agency: Execution of trades on client's behalf
- Heavy use of Market Microstructure
- Spreads, Volume curve, Volatility, Order book depth etc.
- Algorithms
  - VWAP / TWAP
  - Aggressive
  - Passive
  - Liquidity pools and smart order routing
- Hear more and more about agency trading in future

Reliance: Intraday VWAP

Decide with Confidence



Agency trading – VWAP,TWAP

Decide with Confidence

- VWAP: Volume weighed average price
- TWAP: Time weighted average price
- Most widely used benchmark for agency trading performance

$$VWAP = \frac{\sum P_i V_i}{\sum V_i} \qquad TWAP = \frac{\sum P_i T_i}{\sum T_i}$$

- Trade execution as per day's historical volume curve
- Aggressive at buying below the VWAP price and vice versa
- Challenge: Crossing the spread vs. limit order

Agency trading – Inline, Aggressive, Passive

Decide with Confidence

- Inline: Trade executions in-line with the existing trading volume
- Aggressive
  - Directional call
  - Very rapid execution till client set prices
  - Aggressively crosses spreads and absorbs bid / offer
  - Aggressive for fixed time period
  - Implemented when sure about the market direction
  - E.g.: Sniper, Guerilla (CS), Stealth (DB)
- Passive
  - Sits of bid or offer
  - Does not cross spread
  - Waits for fills on limit order, before pushing more volume

Agency trading – Liquidity pools

Decide with Confidence

- Market On Close (MoC) beating trading strategies
- Liquidity pools
  - Primary exchange
  - Secondary exchanges
  - ECN (Electronic Communication Network)
  - Inter-broker dealer
  - Dark-pools
  - Internal crossing
- SOR: Smart Order Routing
- Flash Trading: Flashing orders before routing

Prop algorithms

Decide with Confidence

- Factors
  - Technical: To get the initial trade-start right
  - Statistical/Mathematical: To increase probability of profitability
  - Back test: To get the overall strategy right and systematic
  - Risk assessment
  - Portfolio management and bet sizing
- Algorithms
  - Arbitrage
  - Mean reversion (Stat-arb, Pair trading etc.)
  - Momentum
  - High frequency or Low latency
  - Low frequency – Long/Short

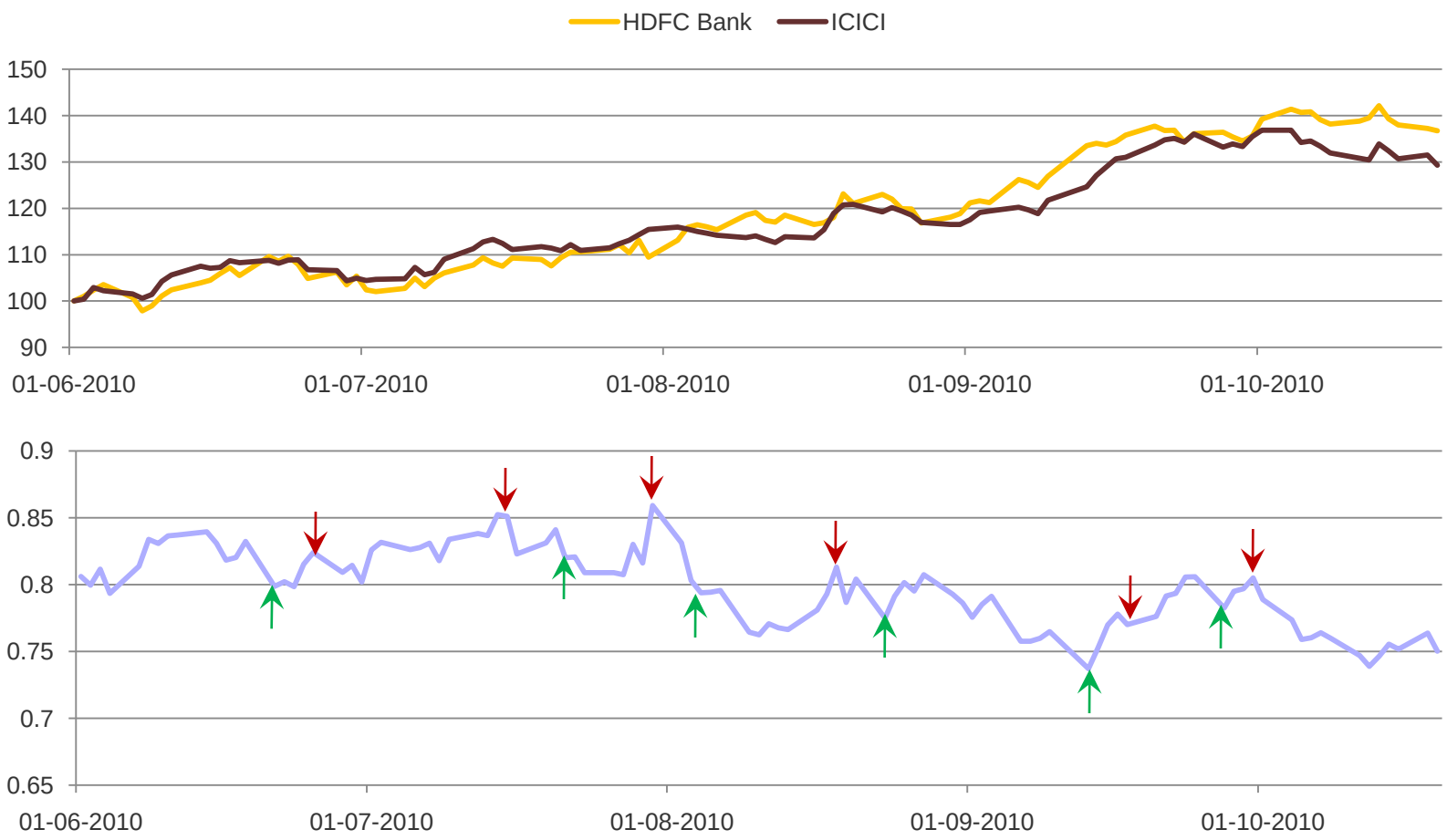
Prop trading – Arbitrage

Decide with Confidence

- Price difference between two or more markets
- Risk based / Risk free
- Simultaneous transactions, Same value
- E.g.: BSE/NSE, cash/future, India/GDR
- Index arbitrage and program trading

Pair trading example

Decide with Confidence



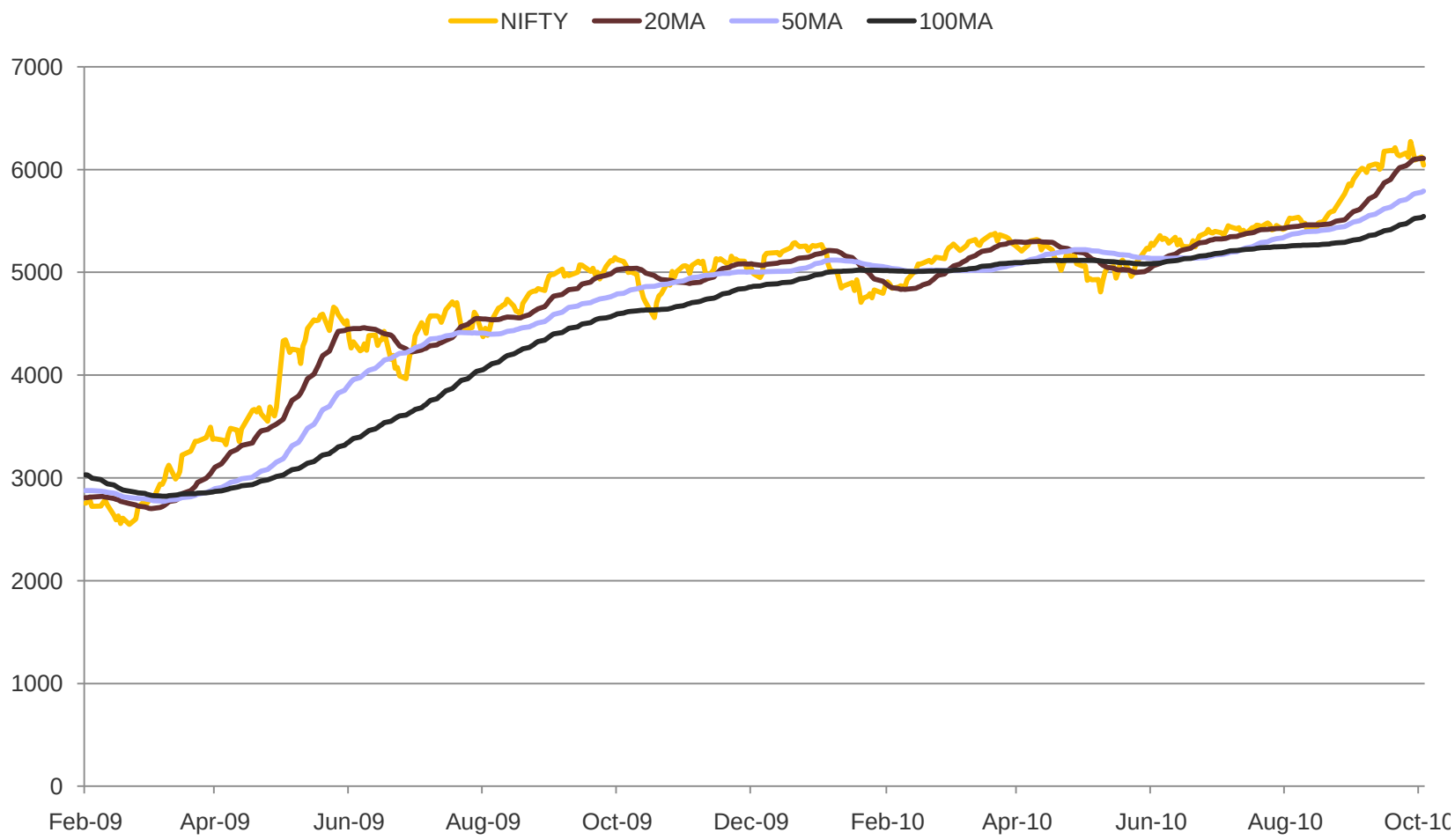
Prop trading – Mean reversion

Decide with Confidence

- Buy on dips, Short on strength
- Bet on convergence of time series
- Single stocks, pairs, baskets of stocks, commodities
- Frequency: weekly, daily, hourly
- Technical: Bollinger bands, RSI
- Statistical
  - Correlation: correlated returns
  - Beta: similar movement in unit returns
  - Co-integration: stationary mean, stationary variance
- Risk : Single stock exposure limits
- Options: Calendar spread, Strike spread

Trend Momentum example

Decide with Confidence



Prop trading – Momentum

- Buy on strength, Short on weakness
- Bet on trend following / continuation of the rally
- Single stocks, futures, index, commodities
- Frequency: weekly, daily, hourly, minute
- Technical: SMA, EMA, MACD
- Statistical:
  - Volatility: Lower volatility is preferred
  - OU process: Non fixed mean time series detection
- Risk
  - Stop loss
  - Money management / Bet sizing
  - Trailing stop losses

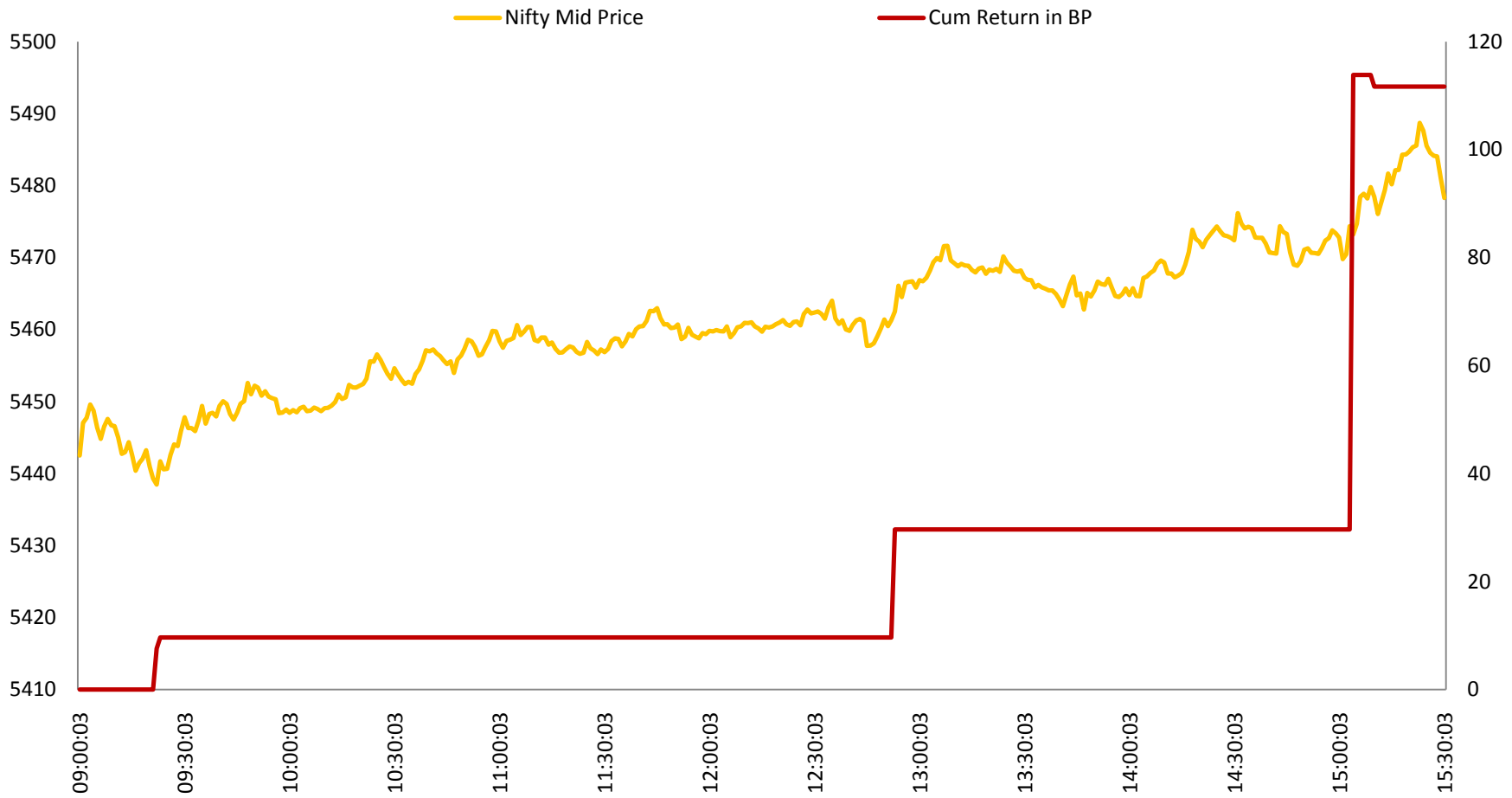
Prop trading – High frequency

Decide with Confidence

- Market-making based on order flow (Sell-side)
- Market-making based on tick data information
- Short term direction based on tick/quote information (Buy side)
- Statistical arbitrage & Automated scalping
- Short holding period: milliseconds to minutes
- Low-latency trading
  - Provides competing bid/offer
  - Trades on demand/supply imbalance
  - Front-run large orders in the network
  - Co-located in exchange and very sensitive to speed
  - “Talk to Trade” ratio

Diagram for HFT

Decide with Confidence



High frequency example

Decide with Confidence

- Bid-Ask Density function using equivalent volumes

$$f(Bid, Ask) = VA_{eq} / VB_{eq}$$

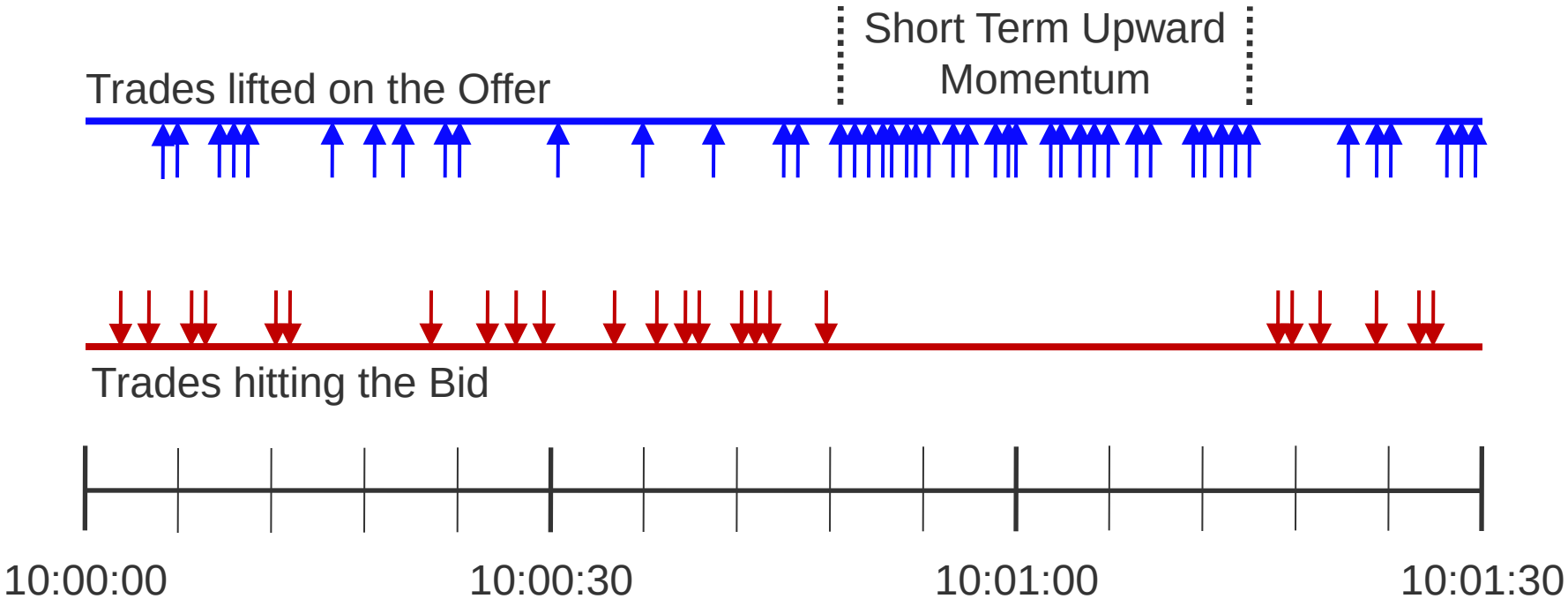
$$VB_{eq} = B_0 + (B_1)^{1/2} + (B_2)^{1/3} + (B_3)^{1/4} + (B_5)^{1/5}$$

$$VA_{eq} = A_0 + (A_1)^{1/2} + (A_2)^{1/3} + (A_3)^{1/4} + (A_5)^{1/5}$$

	1055.00	2
	1054.00	7
	1053.00	15
	1052.00	25
	1051.00	31
	1050.00	
42	1049.00	
20	1048.00	
15	1047.00	
11	1046.00	
6	1045.00	

High frequency example

Decide with Confidence



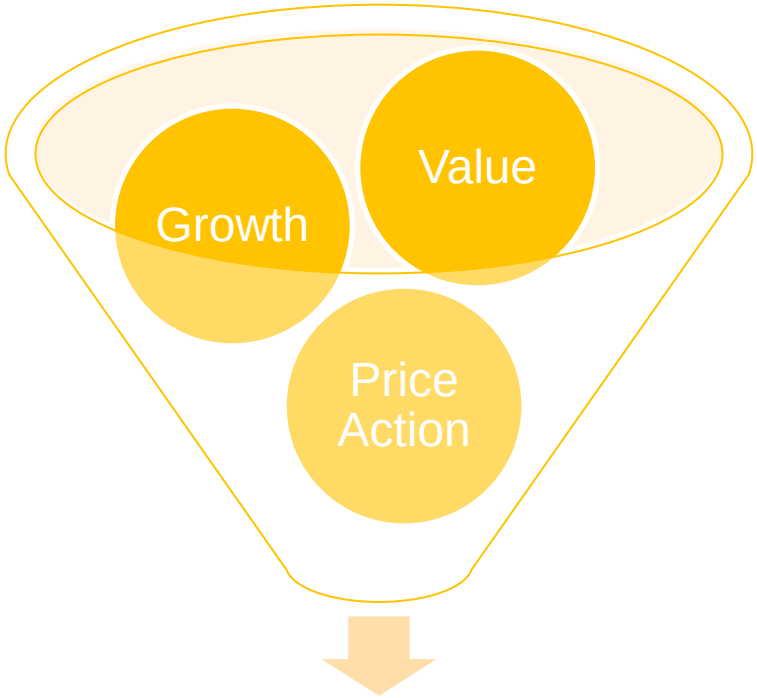
Prop trading – Low frequency, Long/Short

Decide with Confidence

- Equity basket long/short strategy
- Fundamentals based on quantitative techniques
- Growth:
  - 5 years long-term historical growth
  - Forward IBES estimates of next year growth
  - ROE/ROA growth
- Value
  - P/E
  - P/B
  - P/D
- Growth basket: Long top 10% growth stock, Short bottom 10%
- Value basket: Long top 10% value stock, Short bottom 10%

Factor model example

Decide with Confidence



Hybrid Factor Model

Exercises

Decide with Confidence

- Exercise 1: Basic Modeling
- Exercise 2: Time Series Modeling
- Exercise 3: High Frequency Modeling
- Exercise 4: Back testing
- Exercise 5: Variance Ratio Calculation
- **Exercise 6: Alpha Generation**

Session VII:
Business aspect of algorithmic trading

Launch of algorithmic trading

Decide with Confidence

- Priority: Proprietary or Agency trading
- Proprietary trading: higher risk, higher return
- Agency trading: stable source of revenue as commissions
- Most I-banks have both desks and priority differs
- Asset classes: Equities, commodities, interest rates, currency
- Markets: Supports electronic trading

Client driven

Decide with Confidence

- Large Institutional clients want superior execution
  - Agency approach: VWAP, aggressive, passive algorithms
  - Provide intelligence on executing large basket orders
  - Use a mix of sales trader execution and partly algorithms based
  - E.g.: BGI wants to trade large MSCI Index basket
- Clients want quantitative intelligence on trades
  - Quantitative research and algorithmic support
  - Support client-decision making
  - E.g.: Marshall Wace requires analyst ranking data
- HNI / Private banking client wants to manage money
  - Internal quantitative hedge fund approach
  - Manage money on profit sharing basis on internal strategies
  - E.g..: Private banking at most major I-Banks

Product driven

Decide with Confidence

- Internal research and development (Organic route)
  - Product developed first with Prop focus
  - Then AUM deployment holds larger potential
  - Approach clients for deployment of money
  - Enter a profit sharing agreement
  - E.g.: Goldman alpha fund
- Hiring profitable algo desks and quant traders (Inorganic route)
  - Expensive at first go
  - Cut-down the research cycle
  - Aim to generate revenue from day-one based on past track record
  - Sometimes risky as the environment might differ
  - Develop multi-strategy group to act under diverse environment
  - E.g.: Goldman prop desk – always on a look-out

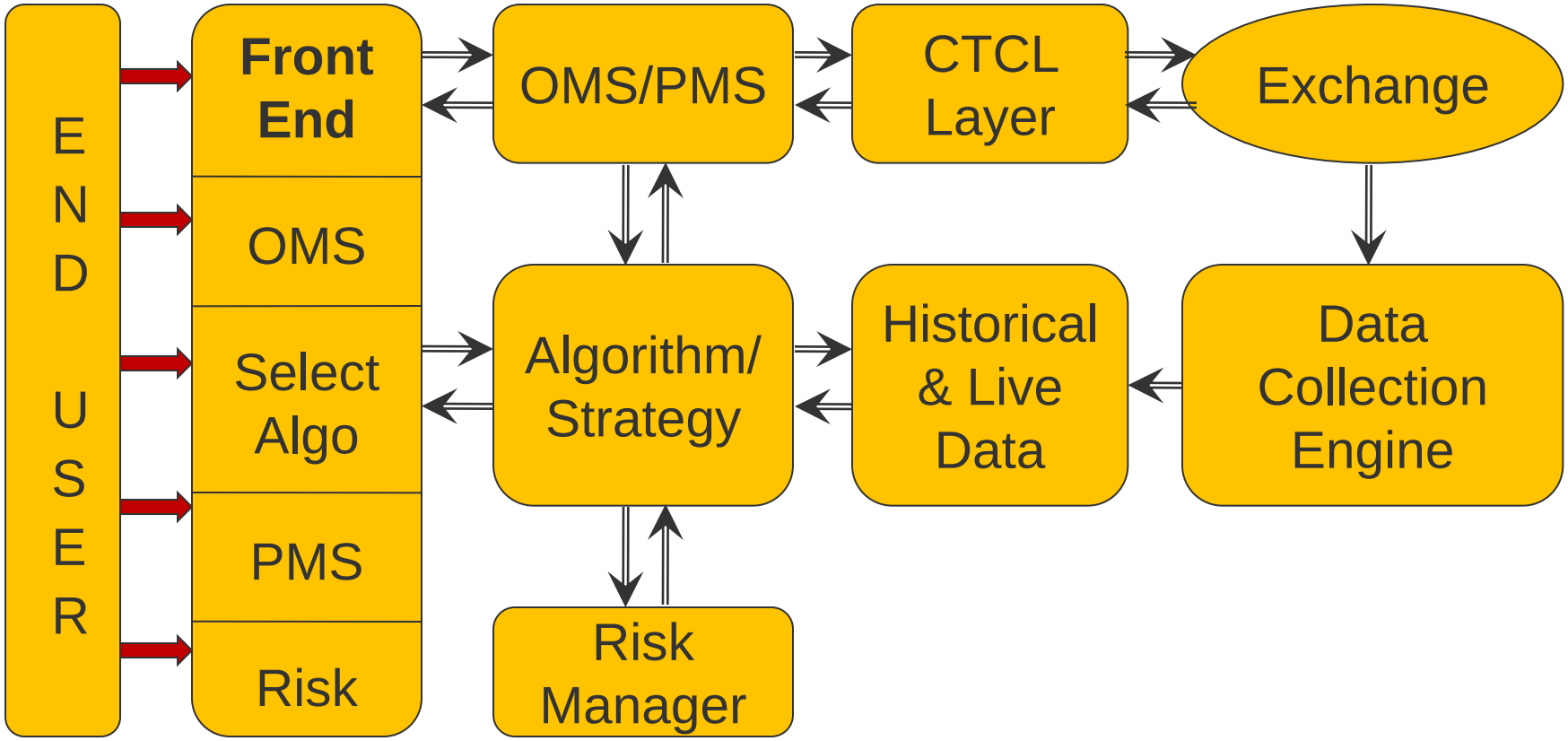
The costs

Decide with Confidence

Cost heads	Per head cost in INR
OMS/PMS system	0 – 10 L
Automated order execution	60 K – 8 L
Data (live time, historical, intra-day, tick-data)	40 K – 3 L
Software (Matlab, Excel, Java, C#, R)	0 – 6 L
Quant Analysts (1 to 5)	2.5 L – 12 L
IT Engineers (1 to 8)	1.3 L – 8 L
Total cost range (Rs. p.a.)	**4.8 L ~ 47 L**

The system integration

Decide with Confidence



Vendor and 3rd party in India

Decide with Confidence

- OMS systems
  - Neat by NSE
  - ODIN by FT
  - Online interface provided by most brokers
- NSE CTCL & BSE IML: Vendors in India
  - 3i
  - Omnesys
  - Greeksoft
  - Financial Technologies
- Data vendor in India
  - Bloomberg
  - Reuters
  - Tickerplant
  - Newswire18

Revenue models in agency algorithms

Decide with Confidence

- Brokerages and Commissions on
  - Single large order at WVAP over multiple days
  - Program trading and basket execution (E.g.: Index arbitrage)
  - Clients strategy execution (E.g.: Pair trading: ICICI-HDFC together)
  - Special executions like beating MOC prices (E.g.: Futures 30 min)
  - Desks in US and Japan makes more than $100 Mn. Annually
- Guaranteed VWAP orders
  - Clients off-load execution risk and execute at average price
  - Prop positioning with clients
  - Desks in US and Japan make more than $25 Mn. Annually
- DMA/DSA
  - Client send orders directly to exchange using broker platform
  - Client choose the execution strategy (VWAP, Aggressive etc.)
  - Client choose the quantity, price and order type directly

Revenue models on prop side

Decide with Confidence

- A good strategy can yield cumulative 25-50% p.a. return
- A good strategy Sharpe ratio is > 2.5
- Diversified strategy
  - Frequencies (High, Medium Low)
  - Strategies (Mean reversion, Momentum)
  - Fundamentals (Growth, Value)
  - Asset classes: Options, Equities, Commodities, Currencies
- Run money
  - In-house
  - Close business associates and friends
  - Clients (usually on a 2/20 hedge-fund model)

Competitive factors

Decide with Confidence

- Competitive edge can be built in
  - Algorithms (Superior alpha factors)
  - Execution
  - Diversification
  - Speed and co-location
  - Brokerage and transaction costs
  - Quantitative & IT team
  - Global outlook and reach to multiple geographies / markets

Exercises

Decide with Confidence

- Exercise 1: Basic Modeling
- Exercise 2: Time Series Modeling
- Exercise 3: High Frequency Modeling
- Exercise 4: Back testing
- Exercise 5: Variance Ratio Calculation
- Exercise 6: Alpha Generation
- **Exercise 7: Risk Management**

Session VIII:
India in algorithmic trading

The exchange regulatory structure

Decide with Confidence

- Unofficial figure quotes that DMA trades
  - 5% of the equities
  - 15% - 25% of the F&O
- Strict exchange regulations
  - Exchanges have throttling control on number of trades per second
  - Approval process for algorithmic trading
  - Multi-exchange algorithmic strategies is not allowed
  - Cross-exchange arbitrage and SOR cannot take place
  - STT applicable to all transactions

The potential

Decide with Confidence

- Indian market is very big!
- 10th largest in dollar value
- Huge potential as in “number of trades” – 3rd largest!
- Worldwide median per trade: $10 K
- India median per trade: $500
- All exchanges offer co-location facilities
- Spreads are amongst the lowest in the world at 5-6 BP

The cost structure – pros and cons

Decide with Confidence

- STT (Securities Transaction Tax)
  - Very high (2 BP in F&O, 12.4 BP in Cash)
  - Deterrent to high-frequency (Making 2-10 BP per trade)
  - Focus on: Intra-day, 10 min. to 3 hour holding strategies
  - Focus on: Medium to low frequency strategies
- The order book depth
  - Indian market lacks depth
  - Execution of 5 lots at once, moves the market
  - Beauty lies in breadth and Signal longevity

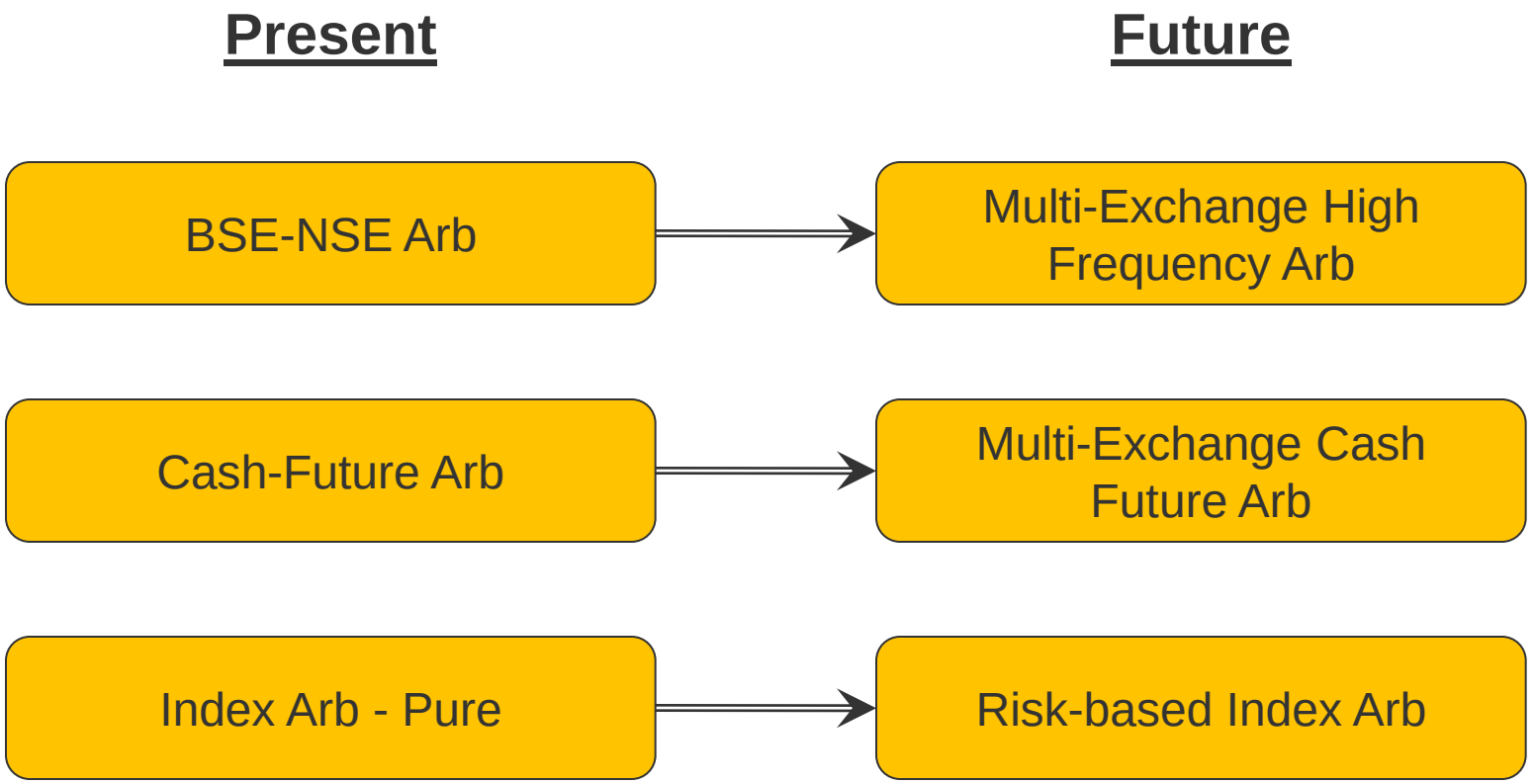
Trends in Indian market

Decide with Confidence

- Proprietary desks
  - Indian brokers have very large prop focus E.g.: Edelweiss
  - Automated trading becoming popular
  - E.g.: Cash-Futures arbitrage, Pure Index arbitrage
  - Big challenge is alpha-generation
- Agency desks
  - Awareness is very little
  - Most foreign brokers have quickly replicated electronic/DMA/DSA
  - Indian brokers slow in adoption
- Major challenges in Agency desk implementation
  - Initial cost to pay-off ratio is very steep
  - Lack of awareness, man-power and skill-set

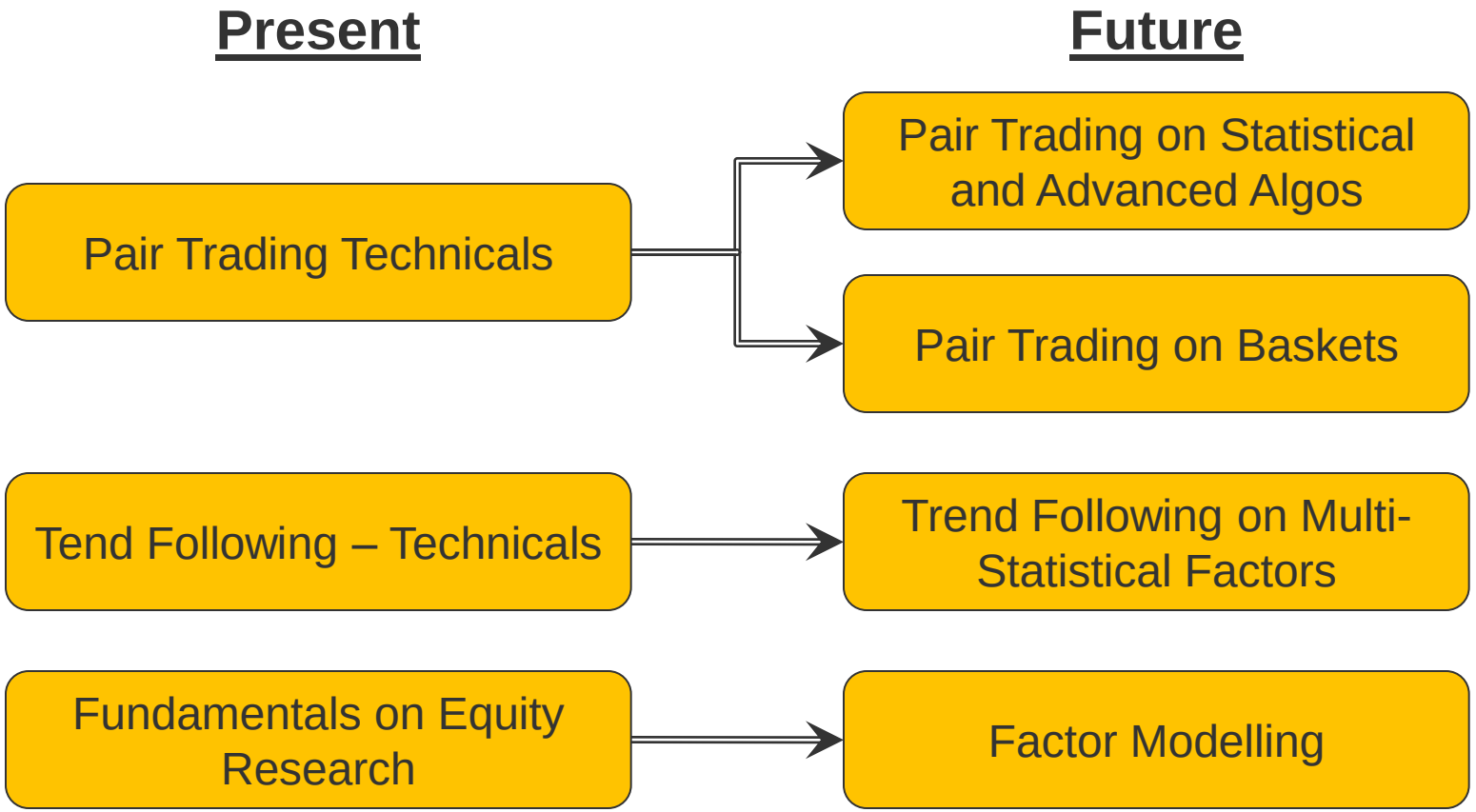
Current state of Algorithmic Trading Prop Algos

Decide with Confidence



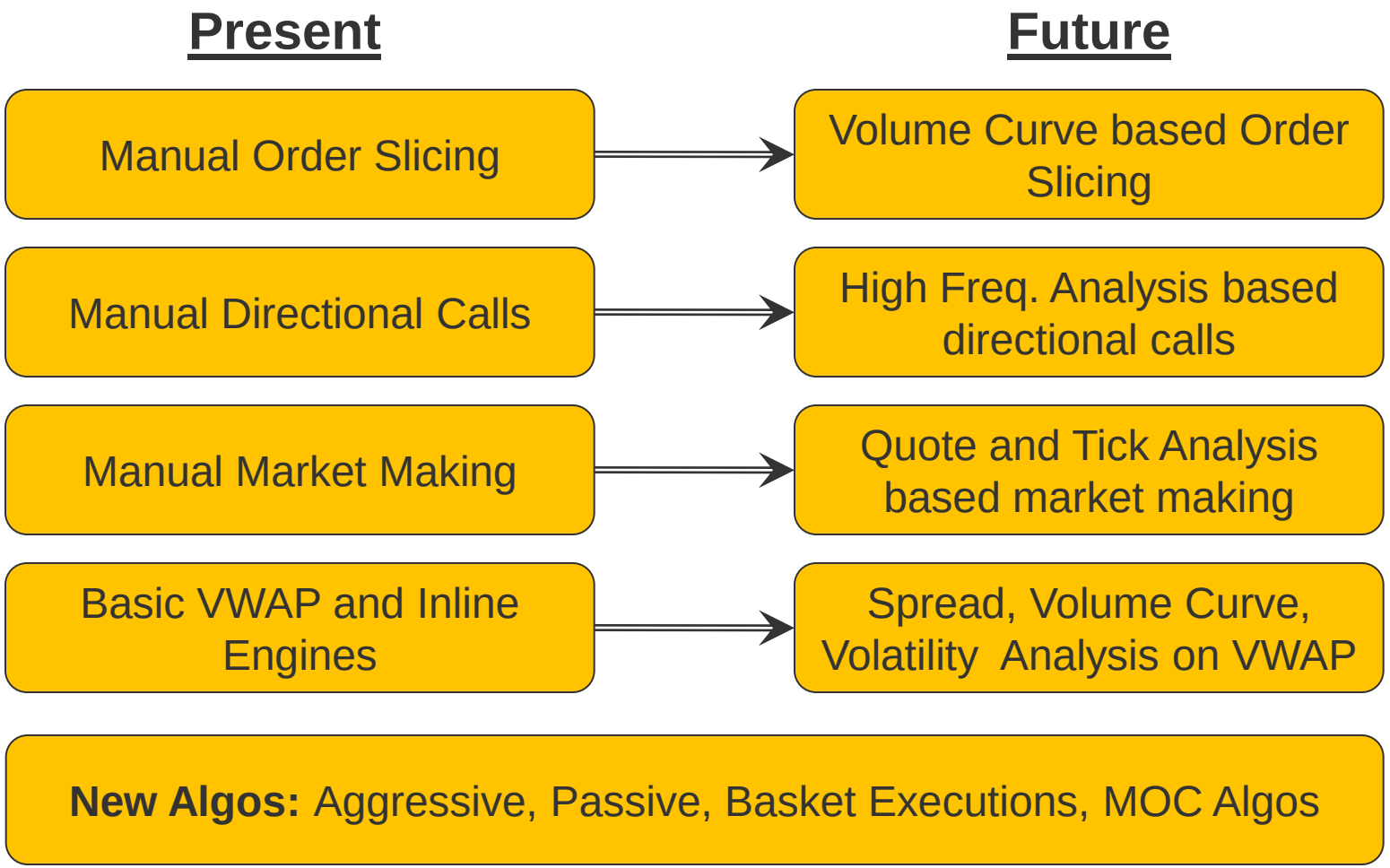
Current state of Algorithmic Trading Prop Algos

Decide with Confidence



Current state of Algorithmic Trading Agency Algos

Decide with Confidence


Present
Future
Manual Order Slicing
Volume Curve based Order Slicing
Manual Directional Calls
High Freq. Analysis based directional calls
Manual Market Making
Quote and Tick Analysis based market making
Basic VWAP and Inline Engines
Spread, Volume Curve, Volatility Analysis on VWAP
New Algos: Aggressive, Passive, Basket Executions, MOC Algos

Exercises

Decide with Confidence

- Exercise 1: Basic Modeling
- Exercise 2: Time Series Modeling
- Exercise 3: High Frequency Modeling
- Exercise 4: Back testing
- Exercise 5: Variance Ratio Calculation
- Exercise 6: Alpha Generation
- Exercise 7: Risk Management
- **Exercise 8: Strategy Evaluation**

A note on retail clients - 1

Decide with Confidence

- Retail clients forms a big part of Indian markets
- Smart thinking and execution is required to tap the retail
- First successful step: online / mobile trading (pure OMS/PMS)
- New ideas and innovation to beat the competition
- Smart execution strategies
  - E.g.: Client wanting to buy 1000 shares of Reliance over the day
  - E.g.: Client wanting to execute a HDFC-ICICI pair at ratio of 2.21
  - E.g.: A client wanting to beat the MOC by last 30 min. execution

A note on retail clients - 2

Decide with Confidence

- Smart portfolio management
  - E.g.: Advising clients on Buy, Hold, Sell based on technical
  - E.g.: Advising clients based on analyst rankings on the stock
- Smart Trade Selection
  - E.g.: Developing automated Intra-day momentum strategies
  - E.g.: Automated Pair-trading strategy which advises 1 or 2 signals in a day

The challenges and positive side

Decide with Confidence

- The challenges
  - Serious lack of skilled man-power
  - Most experienced people are sitting in foreign I-Banks
  - STT (Securities Transaction Tax)
  - Lack of awareness and widespread acceptance
  - Mindset of quick Return on Investments
  - Paying huge upfront costs, getting nothing, leading to frustration
- The positive side
  - Huge pool of IT resources
  - Street smart traders: Good fundamental and technical know-how
  - New generation willing to accept change
  - Tough competition and feeling of left-out on missing an opportunity

The challenges to Indian exchange

Decide with Confidence

- As markets develop – number of algorithms will explode
- Highly trained personnel required for evaluation
- Algorithms might change often and can be very dynamic
- Exchanges might not be able to keep track
- Intellectual property issues will become prevalent
- Exchanges might end in invidious position (blame sharing)
- Strong multi exchange competition
- High pressure on network and bandwidth
- Will require new and strong IT system (E.g.: Japan Arrowhead)

The growth projections

Decide with Confidence

2015-2016: Fully realized HFT at around 30% of volumes similar to international markets

2013-2016: Dark Pools and internalization. Difficult due to regulations and could see delayed implementation

2010-2015: ATS, PTS which are slow to develop due to exchange concentration and regulations

2009-2010: DMA and DSA Evolution

2010-2012: Execution Algorithms on VWAP, TWAP as Co-location and DMA are introduced

2009-2010: Connectivity improves with SOR, exchanges offering co-location, brokers adding multiple connections

Source: Celent Market Research

Recommended referrals

Decide with Confidence

Prop trading

- High-Frequency Trading: A Guide to Algorithmic Strategies and Trading Systems by Irene Aldridge
- Statistical Arbitrage: Algorithmic Trading Insights and Techniques by Andrew Pole
- The Encyclopedia of Trading Strategies by Jeffrey Owen and Donna McCormick

Agency trading

- Algorithmic Trading and DMA: An introduction to direct access trading strategies by Barry Johnson
- Quantitative Trading: How to Build Your Own Algorithmic Trading Business by Ernset P. Chan

Web forums

- Wilmott forum: www.wilmott.com
- Nuclear Phynance: www.nuclearphynance.com

Summary

Decide with Confidence

- The steady race to catch the developed markets in terms of turnover, liquidity, profitability and sustainability in Algorithmic trading has just started.
- Much depends on the regulatory structure, exchange regulations, competitiveness and awareness – as to how the next 3-5 years is going to shape.
- Looking at the global trends India cannot be left far behind in the search for its own space on liquidity generated by Algorithmic trading.
- The big boys of algorithmic trading globally has already started to grab a pie of the growth
- It remains to be seen and sensed whether the domestic players and exchange members are well prepared to take the challenge and compete with the larger players head on to grab a pie of the lucrative business called Algorithmic Trading.